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ROASTED AND GROUND COFFEE - A STUDY OF EXTENDERS, SUBSTITUTES AND ALTERNATIVE COFFEE SOURCES

by
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The purpose of this study was to: 1) evaluate commercially available coffee extenders and substitutes; 2) establish a data base on the effectiveness of extenders and substitutes in event of future increases in coffee bean prices; and 3) design a consumer rating form to acquire sensory information.

The following areas were investigated: 1) reducing the amount of roasted and ground (R&G) coffee in armed Forces Recipe Service (AFRS) guidelines; 2) replacing up to half the R&D coffee with carmel-based extenders; (continued)

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3) one-to-onesubstitution of roast grains for R&G coffee; 4) three miscellaneous products; and 5) substitutions and reblending with African robusta coffee varieties.

Findings indicated that: 1) AFRS recipes could be reduced 25 percent-flavor intensity was reduced but acceptability was unaffected: 2) caramel-based extenders restored beverage color lost by cutting recipe levels - there were significant losses in flavor/taste intensity and some loss in acceptability; 3) at a 50 percent substitution level, R&G wheat significantly reduced flavor/taste attribute ratings; at the same levels, R&G barleys produced no significant changes in acceptability; (4) and a Robusta variety at 30 percent yielded a beverage unchanged in flavor/taste attributes and acceptability from the present blend.

Field data confirmed laboratory findings. Recommendations on advantages and drawbacks to future deployment of extenders, substitutes and alternate varieties are provided.

PREFACE

This project on extenders for roasted and ground coffee was financed with O&MA funds under Production Engineering in support of the DoD Food Program (728012.19000), Task No. Q8032-08 under the title "Sensory Evaluation of Commercially Available Coffee Substitutes and Extenders." The customer was Defense Logistics Agency (DLA), and the project category was Military Adaptation of Commercial Items. A technical plan for the project was originally developed in July 1977, at the time Brazilian coffee bean prices were peaking as a result of the severe 1975 frosts that damaged a significant percentage of the crop. The plan was updated in February 1979 and submitted as an unfinanced requirement as part of the O&MA Five Year Program. Funding was authorized in the Third Quarter FY1980, and work commenced in June of that year. The three services field survey of coffee beverages prepared from roasted and ground coffees with and without a caramel-based extender product was financed by Food Engineering Laboratory (FEL) Task No. Q823126, Support to Armed Forces Product Evaluation Committee. The survey was conducted by research psychologists of the Human Engineering Branch, Behavioral Sciences Division.

The author expresses his appreciation to the following people for their considerable assistance with this study: (1) Mrs. Joan Kalick and the staff of the Sensory Analysis Branch, headed by Dr. Owen Maller, Chief, for their assistance in conducting the laboratory sensory tests; (2) CPT Gerard Smits, Human Engineering Branch, for providing the data, statistical analyses and interpretations in connection with the three Services survey mentioned above; (3) Mr. Norman Harris, FEL, the responsible technologist for roasted and ground coffee, for background information and advisement; (4) Mrs. Mary Klicka, Chief, Experimental Kitchens Branch, FEL, for use of the automatic coffeemaker for the laboratory tests; finally, (5) the numerous coffee trade association and coffee industry personnel, who have been thanked personally but who cannot be mentioned here, for helpful advice, suggestions, and research samples of products and ingredients.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF FIGURES

ROASTED AND GROUND COFFEE: A STUDY OF EXTENDERS, SUBSTITUTES AND ALTERNATE COFFEE SOURCES

INTRODUCTION

Efforts to find extenders for coffee are nearly as old as the product itself. In 1732, J.J. Scheuyer wrote in his Physique Decree about the use of the coffee bean by the Arabs and Turks and also indicated that many persons used the flour of roasted barely as an extender.[1] About 100 years later in England, various substances - particularly chicory, grains, and legume seeds - were used. These, however, were viewed as adulterants because their use with coffee was not disclosed at the point of sale. After a period of scandal and exposure which also involved the use of a colorant, adulteration was still found to be common; however, the numbers of substances used were reduced primarily to chicory and grains. In addition, the extent of adulteration in a product sold as coffee was found to be directly related to its price.[2] The first US brand of packaged coffee was launched in 1873. That same year, the first US patent for a coffee extender (substitute) was issued.[1]

The US military interest in extenders for roasted and ground (R&G) coffee was triggered by the mid-1975 frosts in Brazil, which crippled coffee production. The immediate reaction to the drastic price increases for Brazilian coffee beans, which constituted 70 percent of the military's coffee blend, was a Defense Personnel Support Center and US Army Natick Research and Development Center (NRDC) collaboration in testing a revised blend in which Central American mild coffees were substituted for the Brazilians. Using the consumer populations of several Navy ashore installations and ships, no statistically significant difference in acceptability was found between the existing 70:30 Brazilian: Colombian blend and the revised, all Central American: Colombian blends.[3] This action, as can be seen in Table 1,[4] was likely instrumental in keeping roasted and ground coffee prices to the military (DLA) below $3.00 per pound at the same time prices for consumer coffees rose above $4.00 wholesale. By 1981 new trees planted north of the frost - affected area and other new plantings came into production, which helped restabilize prices.

As may be seen in Table 1, coffee prices dropped after the inception of the project but were still well above the 1976 level.

[1]H. Braxmayer. Coffee substitutes are reborn. Tea & Coffee Trade Journal, 38-39 (1977).

[2]J. Muter. Popular food analysis. No. 2 - Coffee. The Food Journal 1:72-77 (1870).

[3]Plant Products Branch, Food Engineering Laboratory, NRDC. Fact Sheet presented to the Armed Forces Product Evaluation Committee, 12-13 January 1977.

[4]Defense Personnel Support Center (DPSC/DLA) AGRI 188 Printouts for years indicated.

Table 1. DPSC/DLA Canned Coffee Procurements for the U.S. Armed Forces

FY	Dollar Value (Millions)	Pounds (Millions)	Cost/Pound
1976	$14.3	12.5 lb	$1.10
1977	16.1	5.8	2.76
1978	6.3	2.9	2.15
1979	24.5	12.0	2.04
1980	14.3	5.8	2.48
1981	0.9	0.5	1.82
1982	11.9	6.2	1.93
1983	12.8	6.9	1.84

By 1977, a considerable number of coffee extender products, R&G and instant coffee products with extenders added, and coffee substitutes were being marketed for the consumer retail and the food service trade.[5] For purposes of this report, coffee extenders are defined as single products or combinations of ingredients not primarily derived from the coffee bean, the intended use of which is to reduce the amount of coffee usage. In this study extenders were classified into three categories.

1. Caramel Base. Caramel, a colorant used in numerous other food applications, is the predominant ingredient. Also present in the mixture may be a coffee flavor or instant coffee powder, "other botanical extracts," hydrogenated vegetable oil (used to control the dust level when packaging the product), and an anticaking agent, such as calcium phosphate. This product is listed in the Federal Stock Catalog, FSC Group 89 - Subsistence, Class 8955 - Coffee, Tea, and Cocoa. Local procurement is authorized. To use the product the food service unit is instructed to mix the extender with the R&G coffee and reduce the recipe amount of R&G by 40 to 50 percent. The usual ratio is 20 or 22 parts coffee to one part extender. During this project, an active effort took place by vendors to market these products to the military services. Vendor-provided descriptions of the products' function in combination with R&G coffee also included "flavor enhancers," "flavor activators," and "flavor protectors". Proponents' claims typically implied that an equivalent level of coffee flavor strength and acceptability could be maintained when the products were used to replace up to 50 percent of the R&G coffee in a typical brewing recipe.

[5]Anonymous. Industry meets coffee price challenge. Food Product Development, 47; 38-39 (1977).

2. Grains. Roasted and ground (R&G) whole grain wheat or barley are the commercially available materials. The R&G wheat, as offered by one vendor, may be enhanced with coffee oil and other natural coffee flavor. The barley is ordinarily not enhanced with flavoring materials. Typically, the grains are substituted for the coffee in a brewing recipe on a one-to-one basis.

3. Miscellaneous Ingredients and Products. (a) Chicory. A description of chicory is given in the experimental approach section of this report, experiment D-3. (b) Other types. A label declaration for one product evaluated in this study claimed "natural flavor," probably instant coffee; "sodium mineral salts," probably a wetting agent; and tricalcium phosphate, an anticaking agent. The product was to be mixed with coffee at 50 parts coffee to 1 part extender ratio. The extender was said to function as a wetting agent to increase the amount of solids extracted from coffee during brewing. (c) Lastly, instant coffee itself was included in this group as a potential extender product.

Little information exists in the trade or technical literature on the effects of extender use on consumer perceptions of coffee beverage quality and acceptability. Vendor claims regarding these effects have largely been anecdotal and undocumented. Numerous comments have been made by coffee industry technical personnel who have evaluated coffee extenders in their laboratories; unfortunately, however, none of their data have been published. Finally, there existed at the outset of the study no appropriate test form for eliciting such information from consumer judges in laboratory or field settings.

For these reasons, three objectives were established for this study.

1. Using sensory quality and acceptability criteria, the author aimed to develop data on the function and effectiveness of commercially available extenders used in combination with troop issue R&G coffee. At the same time, the study would take into account the relative costs of R&G coffee and the extenders.

2. The study would develop methodology and a rating form for eliciting responses from consumers in laboratory and field settings. The rating form would be sensitive to changes in coffee beverage characteristics brought about by extender use as well as measure acceptability.

3. The study would investigate lower-cost coffee bean sources as part of the troop-issue coffee blend. In pursuing this objective, investigators would reformulate the blend.

EXPERIMENTAL APPROACH

Selection of Panelists

For laboratory tests, it was required that all panelists be coffee drinkers. In the initial stages of the study, all persons listed on the NRDC volunteer employee panelist roster were screened. Those who were coffee drinkers were, in turn, categorized into two groups: One, those who drank coffee black and two, those who drank coffee with added whitener (cream), sugar, or both. Because it was thought that consumption habits might affect ratings, both groups were

initially run separately on the same coffees. However, statistical analyses conducted to test differences between groups, as will be seen, revealed no significant differences between screened groups, either with respect to ratings for quality-related characteristics or for acceptability. Therefore the later tests consisted of people randomly selected from the combined list of coffee drinkers. Nevertheless, information was collected on how coffee had been consumed. As further validation, the screened list of panelists as well as any volunteers were told when contacted that coffee was the test product. Thirty-two to 35 panelists participated in each test and no more than five samples were evaluated per sitting to offset problems of taste adaptation. At field garrison sites, each person observed with coffee on trays or at tables was surveyed. Completed survey card forms were collected at dishwashing windows or from the tables.

Sample Preparation

For laboratory tests, all coffees (with and without extenders) were brewed under identical conditions. The brewer was a Bunn-Omatic Model OT unit; during the study this unit was replaced with a Model F unit made by the same manufacturer. These units were adjusted to deliver sufficient 94°C water through the R&G coffee in the brew basket to fill a 64-fluid ounce glass decanter (approximately 1.9 liters). The brewer was connected to the NRDC well water supply which, in recent determinations analyzed at 170 to 190 ppm hardness (carbonate ion) and 31 mg/L sodium. Both levels were well below sensory thresholds in water determined by Lockhart et al.[6] Water entering the brewer heating reservoir passed through a strainer.

Each batch of coffee was weighed into a fluted paper filter designed for the brewer and placed in the brewbasket. Coffee beverage temperature as it dropped into the glass decanter was 88°C to 90°C. Each test included a reference sample made according to the automatic brewer recipe in the Armed Forces Recipe Service card file.[7] It called for 3¼ oz. av. (90 g) or 1 measuring cup volume per pot. Based upon results from a coffee recipe experiment without extenders conducted as part of this study, the Armed Forces Product Evaluation Committee voted to recommend use of approximately 25 per cent less roasted and ground (R&G) coffee to the Armed Forces Recipe Committee. The latter Committee adopted the recommendation, and it was also adopted as the reference recipe for the balance of this study. The revised formula was 2.5 oz. av. (70 g) or three-quarters of a measuring cup per pot.

[6]E.E. Lockhart, C.L. Tucker and M.C. Merritt. The effect of water impurities on the flavor of brewed coffee. Food Research 20(6): 598-605 (1955).

[7].Recipe Card C, Beverages No. 3, Armed Forces Recipe Service (AFRS), May 1980 Revision. Departments of the Army, Navy and Air Force. Washington, D.C.: U.S. Government Printing Office.

It is emphasized that although the reference recipe was changed during the study, the relationship between "full-strength" recipes and those that included the caramel-based extenders remained the same, i.e., half as much roasted and ground coffee with extender was used.

Sample Presentation

After brewing, beverages were transferred to stainless steel vessels, which were held in a 82°C water bath. Serving temperature was 71°C to 74°C. For each test in which hold time was not a variable, freshly brewed batches were prepared to avoid holding times longer than one-half hour recommended by the recipe. When approximately half the required number of panelists had tested, the batches brewed first were withdrawn and the fresh batches served. For holding time experiments, the held beverages were brewed and placed in the 82°C water bath three hours prior to the test. The "zero hold time" batches were brewed immediately prior to the test. Test sessions required about one additional hour to complete; however, the incremental holding time for both the "fresh" and hold batches was the same for each panelist.

In all tests, samples were presented one at a time to panelists in a balanced random order, i.e., each sample was in the first, second, third... position an equal number of times to avoid the bias of occurring in one position only. All samples in each test were presented "blind," i.e., panelists were totally unaware of test objectives, sample treatments, etc. No codes were used on the serving vessels; however, randomly chosen, two-integer numeric codes were used on the Consumer Option Card test forms. Panelists were seated in partitioned booths which prevented communication with others in the test room.

Homogenized milk was used as the coffee whitener, not only because of its common usage, but also because a liquid nondairy creamer commonly used in the Acceptance Laboratory imparted a sweet characteristic to the coffee, which may not have been desired by those using whitener only. Both whitener and sugar were available in the booths, except when panelists who drank black coffee were selected. Users of one or both these additives (determined by checkoffs on the Consumer Opinion Card) were allowed to add the amounts they customarily used (ad libitum). Care was taken that panelists were consistent in their use or nonuse of whitener or sugar in each sample they evaluated.

Sensory Laboratory Facility

The booth area occupied by panelists was completely separate from the preparation area. Samples were passed through ports between the two areas, which prevented communication between technicians and panelists and also prevented panelists from viewing the preparation area. Panelists entered the booths through a reception area where they received the following posted information on a letterboard: "You will test (number) samples of coffee." Laboratory personnel who were telephoning panelists were not informed about sample treatments and thus could not discuss test objectives with them.

Rating Form

Development of the Consumer Opinion Card, the format of which was finalized as the experiments were being conducted, is detailed in Appendix A of this report.

Extracted Solids Analysis

For many of the laboratory experiments, extracted solids determinations were run on brewed coffee samples to determine the effect of coffee extender products on amount of coffee solubles extracted in brewing. The method recommended by the National Coffee Association was employed. Ten cc of brewed coffee were weighed into a previously weighed and dried aluminum foil dish. Duplicate samples were placed on a steam bath for evaporation to partial dryness which avoided boiling off and loss of solids. Dishes were then transferred to a 105°C vacuum oven where drying continued for three hours. They were then cooled, reweighed and the percent solids computed.

Laboratory Experiments

The following is a list of laboratory evaluations, classified by type of extender. Recipes are indicated in Results and Discussion section tables. All experiments were conducted in the Food Acceptance Laboratory, Sensory Analysis Branch, US Army Natick Research and Development Center.

A. **Roasted and Ground Coffee without Extenders**

Troop Issue R&G Coffee. Three vendors' products were evaluated at full recipe strength to determine whether or not consumer judges could detect any differences among them in quality-related characteristics or acceptability. These were audit products brought in from various military installations, since at the time of this experiment, the troop-issue blend was allowed to fluctuate based upon coffee market prices. If no differences were found among them, any of the three could be used as a full-recipe reference standard or as a base for various extenders and substitutes.

Troop-Issue R&G Coffee without Extenders versus Three Retail Consumer Brands. Test objective was to assess whether quality characteristics and acceptability of troop-issue coffee were equivalent to typical canned R&G coffees sold at retail.

Strength (Recipe) Evaluation, Troop-Issue R&G Coffee. The experimental objective was to determine the effects of varying only the R&G coffee level in the recipe without using extenders. The four recipe levels included were the current reference recipe[7] and one higher and two lower levels than the reference, all differing by 25 percent. Two test sessions were run, one with panelists who drank coffee black and the other with panelists who used both whitener and sugar. In addition to the main objective, this was also one of several methodological experiments to determine (1) the attributes that should be included on the final version of the consumer rating form for coffee and (2) whether consumers groups screened for their coffee drinking habits would exhibit similar rating patterns.

B. Troop-Issue R&G Coffee with Caramel-Based Extenders

Test of Three Commercial Extender Products (E1, E2, E3). Included in the test reference samples without extenders: one was a brew prepared from the full recipe; the other was prepared from half the recipe. Objectives were (1) to determine how the extended brews performed compared to the reference brews and (2) whether any differences in quality and/or acceptability would occur among the extender products. As in the above experiment, two screened consumer panels were used, one, persons who drank their coffee black and, two, persons who used both cream and sugar. The ANOVA used to analyze rating data for each attribute in both this and the preceding experiment also analyzed differences between the two consumer groups.

In preparing R&G coffee samples with extender for brewing, R&G coffee and extender products were weighed separately, combined and hand mixed, then transferred to the automatic brewer paper filter. The ratio was 20 parts coffee and 1 part extender, as recommended in instructions accompanying each extender product.

Commercial Extender at Levels Proportional to Troop-Issue to R&G Coffee. Again, in this investigation two reference standards consisting of full and half recipe troop-issue coffee were included. The Federal Supply Catalog C8900-SL recommended that "the extender when added to R&G coffee in the suggested amount, shall produce an acceptable brew using at least one-third less R&G coffee." In the first of the two samples containing extender, the "one-third less" recommendation was evaluated at the 20:1 coffee: extender ratio. In the second sample, the coffee level was cut to one-half the recommended recipe and the extender level increased proportionally to a 10:1 ratio. This evaluation also served as a means of determining whether a higher extender level in R&G coffee would affect quality-related attributes and/or acceptability. As in the previous two experiments, the two screened consumer groups were run separately and the ANOVA included the analysis for differences between groups.

Evaluation of Three Commercial Preblended Extended R&G Coffees. The preblended extended (PBE) coffees were packaged in premeasured packets for use with automatic brewers. Contents of these packets were used in brewing and the fill weights recorded. Also included in the experiment were troop-issue and an all-Colombian R&G coffee, both brewed at reference recipe levels. Coffee bean blends used in the PBE products were unknown; the same three extenders previously evaluated with troop-issue coffee as the base were represented, however. Consumer panelists who drank their coffee black were selected for the evaluation; whitener and sugar were not available.

PBE R&G Coffees Containing Caramel Extender (E-1). Two blends, of unknown coffee bean composition, were evaluated. Because the base coffee blends without extender were not obtainable, all brewed samples contained the extender product. The experiment served, therefore, as a means of assessing whether or not sensory differences between full and half recipe levels would increase due to any enhancement property the extender might have. This experiment was conducted following an Armed Forces Product Evaluation Committee (AFPEC) decision to recommend reduction of the military coffee recipe by approximately 25 percent without

using an extender product. Thus, 70 g was now the reference recipe level. However, the "full" and "half-recipe" relationship of other experiments in this series was retained. The AFPEC decision was based on results from the recipe experiment without extenders, as well as on existing practices in other food-service organizations. Furthermore, the "half-recipe" R&G coffee levels were in accordance with those typically recommended by PBE vendors. Test form used was the final version of the Consumer Opinion Card for coffee. Coffee beverages were served black to consumer panelists who drank coffee black.

Two R&G Coffee Blends with and without Extenders. One R&G blend, designated as Blend 1, was premixed with the extender E2 evaluated in this series; the other blend, designated Blend 2, was premixed with extender E3. The same blends without these extenders were also provided for this experiment. Composition of the blends was unknown and, from sensory observations made in a prepanel screening, were different. As in other experiments in this series, the beverages without extender were prepared at a full recipe level. Full recipe, in this experiment, was the 90 g level called for by the AFRS card prior to the AFPEC recommendation referred to above. The beverages prepared from the R&G coffees premixed with extender were brewed at the one-half recipe level. All panelists selected for this experiment used both whitener and sugar in their coffee. The vendor supplying these R&G coffees did not specify a recipe level, but recommended using one-half the level of the present recipe.

Institutional R&G Coffee Brand with and without Extender; Commercial PBE Coffee. This experiment was conducted (1) to comply with a request to evaluate the commercial coffees; (2) to determine if troop issue R&G coffee would rate differently from a typical institutional blend with respect to any attributes; (3) to determine if the extender (E2 from this series) would perform differently in another institutional R&G coffee than it had in troop-issue coffee; and (4) to determine if commercial preblending of the extender (E1 from this series) with coffee would produce a brewed beverage different from one prepared from R&G mixed with the extender product immediately before brewing. Troop-issue coffee brewed at the full recipe level was included as the reference. Only the composition (blend) of the troop issue coffee was known. Panelists were randomly selected coffee drinkers from the NRDC roster of volunteers; they were allowed to add whitener, sugar or both to their coffees according to the way they typically drank coffee.

Caramel-based Extender Product with Modified Food Starch and Natural Mineral Ingredients. This product was found late in the project after the other three extender products had been evaluated. Because the starch and mineral ingredients it contained were not part of the item description in the Federal supply Catalog Group 89 (Subsistence), it was evaluated with one of the three other extender products to determine if it would perform differently with troop issue R&G coffee than the other extenders of its type. According to guidelines provided by the vendor, it was to be used at a lower level (approximately 30 parts R&G coffee to 1 part extender) compared to a 20:1 ratio for the other extender (E2). Otherwise, all other conditions were identical to other experiments in this series. Both full and half-recipe troop-issue coffee beverages without extender were included in this test. The mineral ingredient in this extender was said by the vendor to improve the water used in brewing; the starch ingredient was said to prolong brewing time by coating the brewer filter paper.

Holding Time Experiments with R&G Coffees Containing Extender (E-1). Primary objective for this series of four tests was to investigate a claim that this type of extender product would prevent flavor deterioration when brewed coffee is held hot for longer-than-recommended times. Each test consisted of four samples, and the samples and treatments were grouped as follows.

1. Troop-issue coffee without extender at full recipe held for zero and three hours versus PBE coffee at half recipe subjected to the same treatments.

2. Troop-issue without extender versus vendor's R&G coffee preblended with extender. Both coffees brewed at full recipe level and held zero and three hours.

3. Troop-issue coffee mixed with extender product in the laboratory and evaluated at full and half recipe levels at zero and three hours hold time. Coffee: extender ratio was 22:1, as recommended by the vendor.

4. Vendor's PBE coffee preblended with extender, full and half recipe levels held zero and three hours.

C. Roasted and Ground Grains

In this series of experiments, various grains were used to replace R&G coffee on a 1:1 basis in brewing recipes. Roasted wheats and roasted barleys were evaluated.

Roasted and Ground Wheat (RGW). These were enhanced with added natural coffee flavors and coffee oil. Two substitutes were examined in preliminary screening trails, a light and dark roast version. The light roast version at a 50 percent substitution level did not extract well as evidenced by the tea-like transparent appearance of the brew and a preliminary extracted solids determination (0.65 percent compared to 1.1 percent for the full recipe all-coffee and the 50:50 coffee: dark roast wheat substitute brews). On this basis, only the dark roast substitute was subjected to further sensory evaluation. Levels of substitution evaluated were 30 and 50 percent since in the preliminary trials, the brew made from the latter level was characterized as being primarily cereal-like in flavor with low coffee identity. Also included in the evaluation was a consumer grain substituted coffee in which the exact level of substitution, although not formally divulged by the manufacturer, was said to be about 36 percent.

Malted and Unmalted Barleys. These were whole barley grains roasted to approximately a medium coffee-brown color and packed in No. 10 cans. Cans containing the malted grains measured zero vacuum and the malted grains 610 mm vacuum. The samples were submitted to NRDC in June 1977 as events leading to the inception of this project were developing. Cans had been stored for three and one half years at 4°C refrigerator temperatures. When cans were opened, the products appeared to be in excellent condition. This fact was confirmed by preliminary assessments of coffee-barley brews prepared to verify the manufacturer's guidelines on use levels with R&G coffee. Because it was evident that the coffee identity of a brew diminished drastically at a 40 percent

replacement level, that level and a 20 percent level were determined to be appropriate starting points for acceptance panel evaluations. Both barley types were presented to a consumer panel with the 100 percent troop-issue coffee reference beverage. Barley grains were ground in an Osterizer mill at low speed, which resulted in a grind with a high level of small particles (fines). This grind was hand blended with the appropriate amounts of R&G coffee before brewing.

Roasted and Ground Pearled Barley Substitute. This was a commercial product sold as a coffee replacement or brew. It was a roasted and ground pearled (dehulled) barley. Roast level was a light brown color. The product was received ground and packaged in one-pound coated paper bags and had not been subjected to storage stresses. Inasmuch as the product was sold for beverage use on an "as is" basis, as well as for use as an extender, it was decided to replace coffee in 25 percent increments to 100 percent. These four levels of R&G barley were evaluated with the 100 percent reference coffee beverage. Although 75 and 100 percent substitution levels for coffee would not likely be used in practice, it was thought appropriate to determine to what extent the resulting beverage possessed coffee-like attributes.

Medium and Dark Roasted and Ground Whole-Grain Unmalted Barleys. These were freshly-roasted batches produced by the same vendor whose malted and unmalted roast barleys were evaluated in the second experiment in this series. The roasting runs were made on production-scale equipment operated in the late 1970s when several industrial firms, in response to high coffee prices, developed all-grain coffeelike beverages and grain-substituted coffee products for retail sale.

Two separate experiments were conducted on each barley grain roast level at the same extension levels as the above experiment on Roasted and Ground Pearled Barley, and with an all-coffee reference beverage. Barleys were ground before brewing with a Kitchenaid Coffee Mill Model KCM set at the coarsest grind setting. As with other equipment used for grinding, a high proportion of small particles (fines) resulted due to the fragile/brittle character of the roasted grains. When ground, the medium roast color was closest to that of the troop-issue R&G coffee; the dark roast ground barley color was distinctly darker than both the R&G coffee and the medium roast grains.

D. Miscellaneous Extenders

These were products that did not conform to the FSC description or could not be classified under other headings.

Commercial Coffee Extender. The label declaration was: natural flavor, sodium mineral salts and tri-calcium phosphate. The literature provided stated that the product, when used in connection with at least a 40 percent reduction in R&G coffee, would result in an acid-free beverage and approximately a 50 percent caffeine reduction. Conversations with developers of the product also indicated that one of the ingredients functioned as a wetting agent, thereby increasing the amount of solids extracted from R&G coffee. The use level of this product was unclear at the time of the experiment and the product provided

was claimed to be formulated for military use. It was not divulged how the formulation differed from that produced for other institutions. The vendor recommended use of a fine grind R&G coffee (troop issue coffee is a somewhat coarser grind that accommodates a variety of brewing devices).

In this experiment, the reference full and half-recipe R&G coffees were included and two levels of R&G coffee with the extender product were prepared: one beverage was a 40 percent R&G reduction at a 30:1 coffee:extender ratio; the other was a 50 percent reduction at a proportionately lower (25:1) ratio. These recipes were based on an assumption that more extender would be required at lower R&G coffee levels.

R&G Coffee with Instant Coffee Powder as an Extender. This experiment was conducted as a result of a coffee extender Value Engineering proposal submitted by a NRDC food technologist.[8] The suggestion recommended replacement of 50 percent of the R&G coffee with an amount of instant coffee sufficient to make up the loss of extracted solids. In this experiment, both full and half-recipe R&G coffee brews were made up. In addition, each of the two R&G coffee recipes was altered by reducing the R&G coffee by one-half and replacing it with the calculated amount of instant coffee needed to replace the soluble solids that would have been extracted from the R&G coffee. Because troop-issue coffee on hand at the time of this experiment was overage, a fresher commercial R&G coffee on hand was used as the base; a commercial spray dried instant coffee was used as the extender.

R&G Coffees with Chicory. The following is a description of chicory (Cichorum intybus). It is a hardy rooted plant related to the dandelion family. The above-ground leafy portion is endive, a common ingredient of green salads. The roots are grown in France, Belgium, and Holland. At harvest in September, roots are typically 9.0 cm in diameter and 30 cm long. Processing involves trimming, washing and cutting into 2.5 cm pieces, which are air dried overnight. The roasting process is similar to that for coffee beans, except that it is done for a longer time at lower air temperatures to facilitate uniform color development. Roasted pieces are ground in a roller mill and screened to a mesh size of six. The chicory is packed in moisture-proof containers for bulk shipment to U.S. coffee roasters for blending.[9]

Two nationally distributed commercial brands of vacuum canned R&G coffee with chicory were included in the experiment. The chicory level in the blends was not divulged but was said to be in the 35 to 40 percent range. Coffees were brewed according to label directions. A third sample was an institutional R&G coffee whose vendor stated it was unnecessary to use extenders since his low moisture, dark roast and finely ground product would produce a high quality beverage when one-third less than the troop-issue R&G coffee was used. The fourth sample was the reference troop-issue beverage.

[8]N. Harris. Internal communication (1979).

[9]M. Sivetz. Coffee-Origin and Use. Corvallis, OR: Coffee Publications, 1973.

E. Robusta Coffee Beans

During the first year of the project, personnel of the sponsoring agency, DPSC, became interested in alternative coffee varieties as a possible means of cost-reducing the troop-issue coffee blend. Accordingly, investigation of Robusta coffees was programmed for the second year.

Robusta coffee is a botanical variety commonly cultivated in African countries and constitute about one-third of word coffee production. Although the coffees vary in flavor, all are considered harsh in flavor and accordingly less acceptable than the Arabicas (Brazilians, Colombians, etc.) and, hence, command a lower price on the world market. Their caffeine content is two percent, twice that found in the Arabica varieties.[9]. According to the conversations with the National Coffee Association (NCA), about one third of the African production is imported into the U.S., and a number of consumer and private label retail R&G coffee brands contain up to 25 percent Robusta coffee. The NCA also stated there was a great variation among Robusta sources, that they function as a filler to add body to brewed coffee, and, at the time of the experiments, price incentive to use them was lacking.

With the assistance of the NCA and the coffee industry, Robusta coffee bean sources available on a continuing basis in the U.S. were located. They were: Ivory Coast, and Ugandan coffees from Africa and one Indonesian source. The first two sources are listed in the Federal Specification for Coffee.[10] However, at this writing they have not been allowed in procurement contracts which, for purposes of product consistency, have been standardized at 70 percent Brazilian and 30 percent Colombian coffees.

Two approaches were taken to these experiments: first, after benchtop screening trials, R&G Robusta coffees were added to the existing troop-issue blend at various levels, in effect, as a substitute or filler; second, based upon advice from an industry source, the troop-issue blend was reformulated, using different proportions of the Brazilian and Colombian coffees with a selected Robusta source.

For the first step, small batches of whole bean light and medium roast Ivory Coast and Ugandan Robusta coffee beans were provided by the laboratory of a commercial coffee roaster. These were ground and and added to troop-issue canned coffee in five percent increments up to 25 percent to determine roughly at what substitution level the flavor of the Robustas was first noted and then became dominant. Based upon these sensory observations, the medium roast coffees and three substitution levels were selected for inclusion in consumer panel studies.

In the second step, the troop-issue blend was reformulated to include the Robusta coffee (Ivory Coast) beans that, after consideration of sensory and other quality evidence from the preceding studies, were considered best. Upon advice of an industry source the ratio of Brazilian to Colombian was changed to 50:50 and the effects of Robusta level at 20 and 30 percent were investigated.

[10]Federal Specification, Coffee, HHH-C-571E, November 21, 1977.

Two separate studies were conducted: (1) green coffee beans blended before roasting and (2) separately roasted coffee beans blended after roasting. For these trails, green coffee beans were procured from an industrial source and one pound capacity gas-fired batch roasters of a local coffee purveyor were used to roast them to the appropriate levels. Following the laboratory trials, the blend and blending procedure were selected for field (dining hall) trails.

With these experiments, the laboratory investigations were concluded.

Field Evaluation of Coffee Extenders and Alternative Blends

As part of the project, four separate field trails were conducted. The first at Fort Campbell, KY, tested a commercial R&G coffee preblended with a caramel-based extender. In this trail, the amount of extended coffee used in the recipe was one half that customarily used in each dining facility. The second test evaluated roasted and ground barley-substituted coffee at Pease AFB, NH. A third test was of a revised R&G coffee blend containing 30 percent Robusta coffee beans at Fort Devens, MA. The fourth trial was a three-services evaluation of R&G coffee preblended with a caramel-based extender. For this test, reference and sample brewing recipes were tightly controlled.

A. Fort Campbell, KY

Seven dining facilities, primarily serving enlisted personnel, were involved in the survey. The size of the facilities varied from a small NCO unit to consolidated, company-size units. Also included was the Army Hospital Dining Facility. Facilities were allowed to use the recipe and measurement procedure they customarily used for brewing coffee. The level of preblended, extended coffee was then set at one-half that level. It was learned on pre-survey visits to each test site that methods of measuring R&G coffee for brewing were highly variable. Therefore, each food service supervisor was asked to demonstrate how the coffee was measured, and the result was then estimated in terms of volume units on the AFRS recipe card. Six facilities used volume measures other than measuring cups or spoons, e.g., a coffee cup or a soup spoon. The hospital weighed the coffee. Five of the dining facilities used the automatic 12-cup brewers; the hospital and one large consolidated facility were using two-side, three-gallon automatic urns.

Surveying was conducted during a four day period, Tuesday through Friday. Two coffees were evaluated: (1) the canned troop-issue R&G coffee in use at the time at each facility ("full recipe") and (2) a preblended, extended R&G coffee procured by the Base from a local vendor ("half recipe"). The extended coffee product was packaged in eight-oz paper bags with a polymer lining. Bags were folded over and glued; they were not heat sealed. This coffee had been in dry storage approximately a month before the survey visit, and the aroma indicated some staling had occurred. In the original test plan proposal, a third coffee without the extender product had been included, i.e., the vendor's coffee without extender at full recipe, inasmuch as his blend of coffees was not divulged. This, however, was not accepted by the Base or the vendor. The two coffees were served on alternate days at each facility.

On Day 1, four facilities served the extended product and three the troop-issue R&G coffee. The next day, facilities were instructed to serve the other coffee, and so on, through the fourth day. Most surveying was done at the breakfast meal; attempts were made to survey at noon meals but due to low consumption, this was abandoned. Dining facilities provided enlisted food service assistants to help with Consumer Opinion Card distribution and collection.

B. Pease AFB, NH

The enlisted dining facility at this Base was used to evaluate the troop-issue coffee the base was using versus the same R&G coffee substituted with approximately 50 percent dark roasted and ground barley (RGB). This level and roast of barley was found to have a somewhat higher level of coffee-like characteristics than the medium roast barley as well as equal acceptability in laboratory evaluations. Consumer Opinion Cards were handed to all patrons who were observed with coffee on their trays. On day one of the evaluation, the troop-issue coffee in stock was surveyed. The following day, the barley substituted beverage was served and surveyed. Due to lack of a scale on site, measurement of coffee and barley proportions for mixing was by volume. By weight, three standard coffee measures of RGB equalled four measures of R&G coffee. Similarly, measurement for brewing was by volume. An automatic 12-cup brewer was used. Data were collected only at the breakfast meal because observations at other mealtimes revealed coffee consumption to be light.

C. Fort Devens, MA

The purpose of this field trail was to evaluate the present troop-issue blend (70 percent Brazilian, 30 percent Colombian) versus a revised blend that included a Robusta coffee (35 percent Brazilian, 35 percent Colombian and 30 percent Ivory Coast Robusta). The latter blend was found to perform well in laboratory evaluations. All R&G coffee for this test was provided by NRDC to assure that both blends would be of equivalent freshness. Green coffees were procured from a commercial source and pre-roast blended. Thirty pound lots were roasted at the local roasting plant used previously in a gas-fired batch roaster. After roasting, coffee beans were ground to Universal grind specifications and filled into a 15-gallon, sanitary plastic pails with tight, snap-on lids. When the coffee was used in the dining halls, four days had elapsed since roasting and grinding.

Two consolidated dining halls were used for the study and surveyed on two consecutive weekday breakfasts. Order of serving the two blends was balanced between the two facilities. Dining halls were permitted to use their normal recipe for automatic urns, which was close to the AFRS card and approximated one pound per three gallons water at both sites. The appropriate blends were delivered the afternoon prior to the morning used, to avoid confusion by food service personnel as to which coffee to use. Over the two days, 889 valid responses were collected for the troop-issue and 848 for the revised blend. Percentages of patrons taking coffee over the two days ranged from 20 to 25 percent.

D. Three Services Evaluation of R&G Coffee with Caramel-Based Extender

The NRDC was tasked by the Armed Forces Product Evaluation Committee (AFPEC) to evaluate the acceptability to Armed Forces personnel of three coffee recipes. The primary test objective was to determine whether acceptability differed among the recipes. Acceptability was assessed by means of the hedonic scale on the Consumer Opinion Card for coffee.

The three recipes evaluated were:

a. Full strength roasted and ground (R&G);

b. Half strength R&G with Extender;

c. Half strength R&G without Extender.

Recipe A represented the 75% strength brew proposed to Change #1, Armed Forces Recipe Service.[7] Recipes B and C, the reduced R&G levels, represented a reduction in strength to 50% of recipe A.

Test Plan

The experimental design was a Latin square, as shown below.

		1	2	3
	Air Force	A	B	C
TEST	Navy	C	A	B
SITES	Army	B	C	A

A = Full
B = Half strength R&G with Extender
C = Half strength R&G without Extender

As indicated above, the design included three independent variables: test site, order of presentation and coffee recipe. Three sites were used for testing, and each coffee recipe was served at each site. The order of presentation of the recipes was balanced, in accordance with the Latin Square design. Each recipe was tested once during each test period. The order of testing was determined randomly.

Dining facilities were selected by the Services as test sites, two on-base sites (Fort Eustis and Langley AFB) and one shipboard site (USS Emory S. Land, docked at Norfolk Navy Shipyard, VA). Site selection met the following conditions: (a) distribution across the US Army, US Air Force and US Navy; (b) nearness to each other, to facilitate simultaneous testing at all three; (c) an attendance at the dining facilities sufficient to generate an adequate number of customer responses.

Each coffee recipe was served for all meals over a two-day period. Responses were collected during the breakfast and midday meals each day. After the two days of surveying, the next recipe was introduced. Six days of testing were thus required at each site for equal presentation of all three recipes. Because surveying was conducted simultaneously at all three sites, all data collection was completed after one six-day period.

The NRDC-procurred coffee was Coffee, Roasted, Ground, Universal Grind, Blend 3-lb can, FED. SPEC. HHH-C-571, Type (IIIB). The extender (E-1 in Experiment B-1, Results and Discussion) was purchased from a commercial source.

All R&G coffee used for the test was removed from the original containers at NRDC. Coffee for recipes A and C were mixed for 15 minutes in a twin-shell blender, then transferred to a ribbon blender and mixed an additional 15 minutes. The extender product used with the coffee recipe B was added to a portion of the R&G coffee and premixed for 15 minutes in the twin-shell blender. Then, the premix was added to the remaining portion of coffee in the ribbon blender and mixed for an additional 15 minutes. The final coffee: extender ratio was 22:1 per vendor recommendation.

The cans were then labelled "A," and "B," or "C" and shipped to the test sites. Prior to the evaluation, the Army and Navy sites reported using the 100% recipes, whereas the Air Force reported using the revised 75% strength recipe. For this survey, it was decided to instruct all sites to use the 75% strength recipe as the standard brew (recipe A).

At the Army site, coffee was brewed with an automatic urn. At the Navy and Air Force sites, 12-cup automatic coffee makers were used. Coffee preparation during data collection periods (breakfast and midday) was performed by or under the direct supervision of NRDC personnel. A senior NRDC research psychologist supervised data collection at the three sites and monitored coffee beverage preparation. Consumer respondents for this survey were personnel patronizing the dining facilities. Number of responses collected in each Latin square cell ranged from 47 to 160, with an average of 112. A total of 1,010 responses was collected over the six-day period.

Treatments to coffees in the coded containers were known only to NRDC personnel. In addition, food service workers at the sites were unaware of the coffee recipe being used. During mealtimes data collectors approached customers observed drinking coffee with the request "We are interested in your opinion of the coffee you are drinking, would you please fill out this card?" Each customer was handed a response card and asked to drop the completed card in a clearly marked box on leaving the facility. Pencils were provided as needed. Respondents' queries about the type of coffee being served were answered with the statement "We are testing several different kinds of coffee and are interested in how you feel about the coffee you are drinking now." No additional information about the test was volunteered.

Ratings for each quality-related attribute and acceptability were analyzed by analysis of variance (ANOVA). Three main factors were assessed: test site, test day and coffee recipe. The first two factors were incorporated into the model in order to reduce error variance and increase the sensitivity of the statistical test to the differences among recipes. Statistical significance was assessed by a two $\underline{df}$ test of each effect, using a preset $p = 0.05$.

The Latin Square design required the assumption that no interaction exist. The presence of an interaction would confound, to an undetermined

degree, the main effects. For example, a site by time interaction would confound the main effect of coffee. Thus, the statistical analysis (ANOVA) included computation of an interaction term.

RESULTS AND DISCUSSION

Data are reported in the same order that the experiments were outlined in the previous section. Some experiments, as previously indicated, involved trials of alternative attribute scales, which led to finalization of the Consumer Opinion Card for coffee. In these cases, the additional statistical routines employed to correlate these scales with other measures are reported in Appendix A. Also reported with each experiment are analytical data on total extracted solids. In those experiments in which coffee drinkers were selected randomly, the percentages of panelists who used whitener and sugar are reported. For convenient reference, brewing recipes are given for the samples in each table.

Series A. Experiments on R&G Coffee

A. Experiment A-1. R&G Coffee without Extenders

As indicated in Table 2, there were no significant differences among the three troop-issue coffee vendors with respect to five quality-related characteristics of appearance, aroma, flavor, bitterness, mouthfeel or acceptability. Informal sensory observations suggested considerable differences due to blend; for example, beverage No. 1 had a high bitter component while the beverage No. 2 had a mild, aromatic (fragrant) characteristic. However, no significant differences were perceived by the consumer judges on bitterness or aroma scales, respectively. This test suggested that variations in blend were not sufficient to affect consumer ratings and, thus, any source of troop-issue would be suitable as a base for further experiments. Subsequent to this evaluation, Defense Personnel Support Center (DPSC) decided that all future solicitations for R&G coffee would standardize on the 70 percent Brazilian, 30 percent Colombian blend, to minimize the occurrence of field complaints.

B. Experiment A-2. Troop-Issue Coffee versus Popular Consumer Brands

Brand 4 was rated significantly darker in appearance than the other three brands, as indicated in Table 3. It was noted before brewing that its roast level was darker than the other three brands. The only other significant effect from the test was the mouthfeel rating; Brand 1 was rated significantly lower than Brands 3 (troop-issue) and 4. This was unexpected inasmuch as the analyzed extracted solids levels were virtually identical. Perhaps the coffees used in the Brand 1 blend contributed to a different mouth sensation than that experienced by consumers with the other brands. Acceptability levels were low, as they were for the troop-issue coffees evaluated in the previous experiment, A-1. Although not significant, a flake ground coffee (Brand 2) rated lower in strength of coffee flavor and bitterness than the other coffees. The percent solids in the extract was about 0.1 percent lower compared to the 17 percent weight reduction in the recipe. Thus, the

Table 2. Troop-Issue Coffees, Three Vendors

Attributes Rated*	Vendors Number and Formula 1. 90 g	2. 90 g	3. 90 g
Appearance	6.4 ± 1.4	6.0 ± 1.5	6.6 ± 1.1
Coffee Aroma	5.2 ± 2.0	5.2 ± 1.5	5.6 ± 1.7
Coffee Flavor	5.1 ± 2.1	5.2 ± 1.7	5.7 ± 1.5
Bitterness	5.8 ± 2.1	6.2 ± 1.7	5.9 ± 1.6
Mouthfeel	5.2 ± 1.4	5.6 ± 1.2	5.4 ± 1.3
Acceptability	4.6 ± 2.1	4.8 ± 1.8	5.0 ± 1.8
Extracted Solids Analysis (%)	1.03	1.06	1.03

* No significant differences among coffees with respect to any quality characteristics or acceptability. Ratings were by randomly chosen coffee drinkers; no record was kept of whitener and sugar usage since the interim test form used did not request the information. Nine-category scale means are followed by standard deviations.

Table 3. Three Commercial R&G Coffee Brands and Troop-Issue Coffee

Attributes Rated**	Coffee Brand and Recipe* 1. 90 g	2. 75 g	3. 90 g	4. 90 g
Appearance	7.0 ± 1.1b	7.0 ± 1.0b	6.8 ± 1.0b	7.6 ± 0.8a
Strength of Coffee Flavor	6.4 ± 1.8a	5.9 ± 1.7a	6.6 ± 1.6a	6.5 ± 2.0a
Strength of Bitterness	6.4 ± 1.7a	5.9 ± 1.6a	6.5 ± 1.8a	6.2 ± 2.1a
Strength of Sourness	4.9 ± 2.2a	4.7 ± 2.2a	5.1 ± 2.3a	5.1 ± 2.2a
Mouthfeel	4.9 ± 1.8b	5.2 ± 1.4ab	5.8 ± 1.3a	5.8 ± 1.4a
Acceptability	4.5 ± 2.1a	4.8 ± 1.9a	5.2 ± 2.0a	4.7 ± 2.0a
Extracted Solids Analysis (%)	1.06	0.92	1.08	1.01

* Brand 3 was Troop-Issue coffee. Brand 2 was a flake ground coffee; recipe was that recommended for a "13 ounce pound."

** For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$). Consumers selected drank coffee black.

"extension" of R&G coffee through alteration of the roasting and grinding process (reducing bulk density) would appear to have merit.

C. Experiment A-3. Strength (Recipe) Test, Troop-Issue Coffee

Data are presented in Table 4. Averaged across the two consumer groups, there were no significant differences between the 125 percent and reference (100 percent) recipes in appearance, coffee aroma, bitterness, and mouthfeel. With these same attributes, there were significant decreases in ratings between each incremental decrease in recipe below the reference level. With respect to acceptability, the 75 percent recipe was rated significantly higher than the 50 percent, and ratings among the 125, reference and 75 percent recipes did not differ significantly. Although consumer panelists demonstrated they could distinguish between reference and 75 percent recipe levels on the basis of the five quality-related attributes, there was no corresponding difference in acceptability ratings between these two recipes. It should be noted that, as ratings for attributes such as bitterness and coffee flavor decreased, acceptability ratings increased marginally until the 50 percent recipe was reached. This suggested that, on the basis of acceptability alone, the present coffee brewing recipe could be further optimized by a 25 percent reduction in recipe without the use of extender products.

Evidence for the bitterness-acceptability relationship can be observed in Appendix A where a slightly negative correlation coefficient can be noted; also contained in this Appendix are the other attribute correlations from this experiment, which lead to further refinement of the consumer rating form.

Series B. Caramel-Based Extenders

A. Experiment B-1. Three Commercially Available Coffee Extender Products

Results are given in Table 5. Consumer panelists perceived the coffee beverages with extender to be darker in appearance than the reference recipe without extender. The group using whitener and sugar rated the reference and one-half reference recipe beverages darker than the group who drank the coffee black. The extent of the difference was unexpected, but it should be noted that panelists were instructed to make the judgment before adding whitener. This difference in ratings resulted in a significant F-ratio between groups. In addition, there was a significant coffee-consumer group interaction for appearance, not shown in the table.

Similar rating patterns were observed with the coffee flavor, bitterness, and sourness attributes. The reference recipe beverage rated significantly higher than the three coffee plus extender beverages which in turn rated higher than the half reference recipe beverage without extender. Adding the extender products to a half recipe level of R&G coffee produced an apparent enhancement of coffee flavor strength compared with the half recipe coffee beverage without extender. Panel ratings, however, may have been biased by the dark appearance of the beverages. This observation carried over, to some degree, to the bitterness attribute wherein the extended beverages were rated somewhat more bitter than the half recipe coffee. The same relationship

Table 4. Strength (Recipe) Evaluation, Troop Issue R&G Coffee without Extenders

Attributes Rated	Formula % Of Ref.	Grams	Consumer Group: Drank Black	Used Whitener & Sugar	Combined Group Means**	F-Ratio Groups
			(N=32)	(N=32)	(N=64)	(1,62)
Appearance	125	112.5	7.3 ± 1.1	6.8 ± 1.3	7.0 ± 1.2a	0.76, NS
	100	90.0	6.9 ± 1.3	6.7 ± 1.3	6.8 ± 1.3a	
	75	67.5	6.0 ± 1.6	5.8 ± 1.4	5.9 ± 1.5b	
	50	45.0	4.4 ± 1.6	4.4 ± 1.5	4.4 ± 1.5c	
Coffee Aroma	125	112.5	5.5 ± 2.0	5.7 ± 1.7	5.6 ± 1.8a	0.72, NS
	100	90.0	5.3 ± 1.9	5.3 ± 1.9	5.3 ± 1.9a	
	75	67.5	4.4 ± 1.9	5.0 ± 1.3	4.7 ± 1.6b	
	50	45.0	3.3 ± 1.8	3.7 ± 1.6	3.5 ± 1.7c	
Coffee Flavor	125	112.5	6.4 ± 1.5	5.8 ± 1.8	6.1 ± 1.7a	1.95, NS
	100	90.0	5.9 ± 1.7	5.3 ± 2.1	5.6 ± 1.9b	
	75	67.5	5.0 ± 2.0	5.0 ± 1.8	5.0 ± 1.9c	
	50	45.0	4.2 ± 1.9	3.5 ± 1.6	3.9 ± 1.8d	
Bitterness	125	112.5	6.2 ± 2.1	6.3 ± 1.3	6.2 ± 1.7a	2.57, NS
	100	90.0	6.3 ± 1.4	5.2 ± 2.4	5.7 ± 2.0a	
	75	67.5	5.2 ± 2.0	4.8 ± 2.0	5.0 ± 2.0b	
	50	45.0	4.2 ± 1.9	3.4 ± 1.8	3.8 ± 1.9c	
Mouthfeel	125	112.5	6.0 ± 1.4	5.7 ± 1.5	5.8 ± 1.4a	2.34, NS
	100	90.0	6.0 ± 1.3	5.2 ± 1.7	5.6 ± 1.5a	
	75	67.5	5.2 ± 1.5	5.2 ± 0.9	5.2 ± 1.2b	
	50	45.0	4.3 ± 1.6	3.9 ± 1.3	4.1 ± 1.5c	
Acceptability	125	112.5	5.0 ± 1.8	4.9 ± 1.8	5.0 ± 1.8ab	0.27, NS
	100	90.0	5.2 ± 1.8	5.2 ± 2.3	5.2 ± 2.0ab	
	75	67.5	5.4 ± 1.7	5.2 ± 1.8	5.3 ± 1.7a	
	50	45.0	4.7 ± 2.0	4.4 ± 1.8	4.6 ± 1.9b	

* Extracted solids levels, in percent for the four beverages were as follows: 112.5 g, 1.38; 90 g, 1.05; 67.5 g, 0.7a; 45 g, 0.53. Data are averages of two duplicate determinations.

** For each attribute, combined group means followed by different letters are significantly different ($p \leq 0.05$).

Table 5. Evaluation of Three Caramel-Based Extender Products

Attributes Rated	Recipe* Grms. Coffee + Grms Extender (E)	Consumer Group: Drank Black	Used Whitener & Sugar	Combined Group Means**	F-Ratio Groups
		(N=35)	(N=35)	(N=70)	(1,68)
Appearance (Before adding cream)	90 + 0 (Reference)	6.6 ± 1.1	7.3 ± 1.2	6.9b	5.43, significant at P=0.02
	45 + 0	3.2 ± 1.3	5.1 ± 1.7	4.1c	
	45 + 2.25 (E1)	8.1 ± 1.0	7.8 ± 1.1	8.0ab	
	45 + 2.25 (E2)	8.1 ± 0.9	8.2 ± 0.8	8.2a	
	45 + 2.25 (E3)	7.6 ± 1.0	7.7 ± 1.1	7.6ab	
Strength of Coffee Flavor	90 + 0 (Reference)	6.6 ± 1.7	6.9 ± 1.3	6.5a	2.71, not significant
	45 + 0	3.6 ± 1.9	4.3 ± 1.9	3.9c	
	45 + 2.25 (E1)	5.4 ± 1.5	5.2 ± 1.9	5.3b	
	45 + 2.25 (E2)	5.2 ± 1.8	5.8 ± 1.9	5.5b	
	45 + 2.25 (E3)	5.7 ± 1.8	5.9 ± 1.8	5.8b	
Strength of Bitterness	90 + 0 (Reference)	6.4 ± 1.7	6.4 ± 1.6	6.4a	0.00, not significant
	45 + 0	3.7 ± 1.9	4.6 ± 2.3	4.2c	
	45 + 2.25 (E1)	4.8 ± 1.8	4.3 ± 1.9	4.5bc	
	45 + 2.25 (E2)	4.7 ± 1.9	4.5 ± 2.2	4.6bc	
	45 + 2.25 (E3)	5.2 ± 1.9	5.0 ± 2.1	5.1b	
Strength of Sourness	90 + 0 (Reference)	4.9 ± 2.2	4.4 ± 2.5	4.7a	0.11, not significant
	45 + 0	3.2 ± 1.8	3.7 ± 2.1	3.5c	
	45 + 2.25 (E1)	3.8 ± 2.0	3.6 ± 1.7	3.7bc	
	45 + 2.25 (E2)	4.0 ± 1.8	3.6 ± 2.0	3.8bc	
	45 + 2.25 (E3)	4.2 ± 2.2	4.1 ± 2.2	4.2b	
Strength of Sourness	90 + 0 (Reference)	5.3 ± 1.3	5.7 ± 1.3	5.5a	2.31, not significant
	45 + 0	3.5 ± 1.3	4.3 ± 1.5	3.9c	
	45 + 2.25 (E1)	4.8 ± 1.5	5.2 ± 1.4	5.0b	
	45 + 2.25 (E2)	5.0 ± 1.4	5.2 ± 1.5	5.1ab	
	45 + 2.25 (E3)	5.5 ± 1.2	5.3 ± 1.4	5.4ab	
Acceptability	90 + 0 (Reference)	4.9 ± 2.0	4.8 ± 2.4	4.8ab	0.29, not significant
	45 + 0	4.3 ± 1.9	4.7 ± 1.6	4.5b	
	45 + 2.25 (E1)	5.6 ± 1.7	5.6 ± 1.9	5.6a	
	45 + 2.25 (E2)	5.4 ± 1.6	5.8 ± 1.5	5.6a	
	45 + 2.25 (E3)	5.6 ± 1.8	5.4 ± 2.0	5.5a	

* Extracted solids levels in percent, for the five beverages were as follows: (1) 90 + 0, 1.09; 45 + 0, 0.54; 45 + E1, 0.73; 45 + E2, 0.77; 45 + E3, 0.79. Data are averages of two duplicate determinations.

** The BMDPZV Program (Health Science Computing Facility, University of California, Los Angeles), used to compute the ANOVA, did not provide standard deviations for means computed across groups. For each attribute, combined group means followed by different letters are significantly different ($p \leq 0.05$).

occurred for sourness which was not as intensely perceived an attribute as bitterness. For all three attributes, however, the reference recipe beverage rated significantly higher than all other treatments. Although producers of these extender products claim reduction of bitterness and coffee acids through use of their products, the claim is not supported when comparing equal R&G recipe levels with and without extender. The claim would only seem supportable if the R&G coffee level itself was reduced.

Ratings for the mouthfeel attributes were equivalent between the reference recipe and the extended coffees, but the half recipe beverage without extender was rated significantly thinner than all other samples. (For scale used in this experiment, see Figure 1, Appendix A.) Again, the dark appearance of the extended beverages may have produced the impression of a heavier mouthfeel. The extracted solid analyses (see footnote*, Table 4) did not support the observed equivalency of ratings; however, at these relatively low levels, sensory differences may either have been imperceptible or a reaction to differences in other attributes such as strength of coffee flavor.

Acceptability of coffee beverages with extenders was higher than the full recipe beverage without extender but the difference was not statistically significant. Again, as will be noted in Appendix A, Table A-1, there was a slight but nonsignificant negative correlation between bitterness and acceptability. This may explain in part the apparent increase in acceptability. Half-recipe coffees with extender were significantly higher-rated than the half-recipe beverage without extender, which followed the same trend as for the coffee flavor attribute.

A significant finding was that, from a sensory viewpoint and regardless of ingredient and formula variations, the commercial caramel-based extenders used in this experiment were generically identical. Thus, if a caramel-based extender product meets the requirements of the FSC listed item, no significant sensory differences in performance would be expected.

B. Experiment B-2. Investigation of a Commercial Extender at Levels Proportional to the R&G Coffee Recipe

Because caramel-base extender products were found to function generically in combination with R&G coffee in the previous experiment (B-1), the E2 product from that experiment was arbitrarily selected for this investigation. Results are presented in Table 6. As in the previous experiment (B-1), the appearance of the beverages with extender was judged significantly darker than the beverage without extender; it should be noted that there was no difference in darkness between the extended beverages even though the 10:1 coffee: extender ratio beverage contained a 50 percent higher extender level than the 20:1 ratio beverage.

Similar rating patterns as those observed in experiment B-1 were observed for the coffee flavor, bitterness, and sourness strength scales. The reference recipe had the highest perceived strength on all three scales; the difference between reference and extended beverages was significant for bitterness and sourness. The 10:1 ratio beverage was rated significantly

Table 6. Extender E2 Used at Levels Proportional to R&G Coffee in Recipe

Attributes Rated	Recipe* Grms. Coffee + Grms Extender (E2)	Consumer Group: Drank Black (N=33)	Used Whitener & Sugar (N=34)	Combined Group Means** (N=67)	F-Ratio Groups (1,65)
Appearance (Before adding cream)	90 + 0 (Reference)	6.5 ± 1.4b	6.5 ± 1.2b	6.5 ± 1.3b	0.61, not significant
	45 + 0	3.4 ± 1.7c	4.1 ± 1.8c	3.7 ± 1.8c	
	60 + 3.0 (20:1)	7.8 ± 0.9a	8.0 ± 0.9a	7.9 ± 0.9a	
	45 + 4.5 (10:1)	8.2 ± 1.0a	7.9 ± 1.2a	8.0 ± 1.1a	
Strength of Coffee Flavor	90 + 0 (Reference)	6.1 ± 1.8b	6.3 ± 1.5a	6.2 ± 1.6a	0.54, not significant
	45 + 0	3.5 ± 1.9c	3.9 ± 1.5b	3.7 ± 1.7c	
	60 + 3.0 (20:1)	6.0 ± 1.8a	5.9 ± 1.8a	5.9 ± 1.8ab	
	45 + 4.5 (10:1)	5.3 ± 2.0b	5.7 ± 1.6a	5.5 ± 1.8b	
Strength of Bitterness	90 + 0 (Reference)	6.1 ± 1.9a	6.3 ± 1.8a	6.2 ± 1.8a	0.20, not significant
	45 + 0	4.2 ± 2.0c	4.1 ± 2.0c	4.1 ± 1.9c	
	60 + 3.0 (20:1)	5.4 ± 1.7ab	5.1 ± 1.9b	5.3 ± 1.8b	
	45 + 4.5 (10:1)	5.0 ± 2.1b	4.6 ± 1.7bc	4.8 ± 1.9b	
Strength of Sourness	90 + 0 (Reference)	4.8 ± 2.0a	4.6 ± 2.4a	4.7 ± 2.2a	0.63, not significant
	45 + 0	3.5 ± 1.8b	3.7 ± 2.2b	3.6 ± 2.0b	
	60 + 3.0 (20:1)	4.6 ± 2.2a	3.7 ± 2.1b	4.1 ± 2.2b	
	45 + 4.5 (10:1)	4.1 ± 2.2ab	3.6 ± 2.3b	3.9 ± 2.2b	
Mouthfeel	90 + 0 (Reference)	5.1 ± 1.5a	5.5 ± 1.3a	5.3 ± 1.4a	0.51, not significant
	45 + 0	3.8 ± 1.6b	3.9 ± 1.5b	3.9 ± 1.5b	
	60 + 3.0 (20:1)	5.1 ± 1.2a	5.3 ± 1.4a	5.2 ± 1.3a	
	45 + 4.5 (10:1)	5.2 ± 1.6a	5.3 ± 1.2a	5.3 ± 1.4a	
Acceptability	90 + 0 (Reference)	5.1 ± 1.8a	4.9 ± 2.1b	5.0 ± 1.9a	2.94, not significant
	45 + 0	4.0 ± 1.7b	4.8 ± 1.7b	4.4 ± 1.8b	
	60 + 3.0 (20:1)	5.1 ± 1.8a	5.6 ± 1.9ab	5.4 ± 1.8a	
	45 + 4.5 (10:1)	4.8 ± 1.8a	5.9 ± 1.9a	5.3 ± 1.9a	

* Extracted solids levels in percent, for the four coffee + extender beverages were as follows: (1) 90 + 0, 1.04; 45 + 0, 0.55; 60 + 3.0, 0.88; 45 + 4.5, 0.77. Data are averages of two duplicate determinations.

** For each attribute, combined group means followed by different letters are significantly different ($p \leq 0.05$).

higher in coffee flavor and bitterness than the half recipe coffee without extender. These data were evidence that using a higher extender level would not increase the perceived levels of these attributes compared to an extended coffee beverage made from more R&G coffee ingredient and a lower extender level. There was a consistent decrease in ratings, i.e., the less coffee in the combination, the lower the ratings.

On mouthfeel, the reference recipe and extended beverages received equivalent ratings, and the half recipe beverage without extender was rated significantly lower than these three samples. As in experiment B-1, a biasing factor may have been the appearance cue, i.e., the high darkness levels of the extended beverages.

As in the previous experiment (B-1), although extended beverages were rated higher, there was no significant difference in acceptability between them and the reference-recipe beverage. This occurred even though significant differences in taste-related attribute ratings were found between the same samples. Finally, acceptability of the half-recipe beverage without extender was significantly less than the other three beverages. Because no significant differences were found in flavor/taste attribute ratings when coffee and extender levels were manipulated, it was decided to discontinue further experimentation in this area and follow vendor recommendations regarding recipe and ratio of coffee to extender, typically 20:1.

C. Experiment B-3. Evaluation of Three Commercial Preblended Extended R&G Coffees

Results are given in Table 7. In appearance, PBE coffees 2 and 3 were rated significantly darker than the reference recipe troop-issue and all-Colombian coffees. PBE coffee 1 was rated equivalent to troop-issue in appearance, likely because the fill weight of the packets was about 16.5 percent less than PBE coffee 3 which was equivalent to one-half the reference recipe. The all-Colombian R&G was perceived the lightest in appearance, which may have been due to the observed light color of the roast (lighter than troop issue).

With the extended coffee beverages, ratings for the taste-related qualities seemed related to the fill weights of the packets. Ratings for coffee flavor, bitterness and sourness were significantly higher for PBE coffee 3 (highest fill weight) than for PBE coffee 1 (lowest fill weight); although a trend was evident, ratings for these attributes between PBE coffee 3 and PBE coffee 2 were not significant. Differences in bitterness and sourness were not significant between troop-issue and PBE coffee beverage 3; this result may be explained by benchtop observations that described PBE coffee 3 as "burnt" in aroma and flavor. Differences in the three attributes, however, between troop-issue and the other two PBE beverages were significant. The all-Colombian beverage rated significantly lower in coffee flavor than troop-issue, a function perhaps of "noncoffee" characteristics observed in the beverage, i.e., weedy, solventy, green, and earthy.

Table 7. Three Commercial Preblended Extended (PBE) R&G Coffees

	Troop Issue	All-Colombian	PBE Coffee No. 1 with Extender E1	PBE Coffee No. 2 with Extender E2	PBE Coffee No. 3 with Extender E3
Recipe/Packet Weight (gms)	90	90	38*	42.5*	45.5*
Extracted Solids (%)	1.09**	0.92	0.46	0.56	0.64
Attributes+					
Appearance (Before adding cream)	6.6 ± 1.2b+	5.5 ± 1.6c	6.4 + 1.5b	7.6 ± 1.4a	7.7 ± 1.4a
Strength of Coffee Flavor	6.6 ± 1.9a	5.6 ± 2.0b	4.6 ± 2.0c	5.4 ± 2.0b	5.8 ± 2.2b
Strength of Bitterness	6.2 ± 1.8a	6.1 ± 1.9a	4.5 ± 2.2c	5.2 ± 2.1bc	5.8 ± 2.1ab
Strength of Sourness	6.0 ± 2.0a	5.8 ± 2.1a	4.2 ± 2.2c	4.6 ± 2.3bc	5.2 ± 2.3ab
Mouthfeel	6.2 ± 1.5a	5.4 ± 1.6b	4.5 ± 1.9c	5.0 ± 1.8bc	5.5 ± 1.6b
Acceptability	4.9 ± 2.4a	4.0 ± 1.9a	4.2 ± 1.9a	4.1 ± 2.0a	4.2 ± 1.9a

* Average weights of two packets.

** Average of two determinations.

\+ For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$). Number of panelists = 40.

Differences in the mouthfeel attribute also seemed related to packet weights of the PBE coffees; the troop-issue beverage was rated significantly heavier in mouthfeel than all PBE coffees. The all-Colombian beverage rated significantly lower than troop-issue in this attribute, again perhaps a function of its noncoffee character. Finally, in acceptability, the troop-issue beverage was rated higher than all other beverages, but the difference was not significant.

Results of this experiment should be interpreted with caution inasmuch as significant differences in attribute ratings among the PBE coffees may not arise from the extender products but from differences in (1) fill weights of packets; (2) green coffee blends; (3) roast level, and (4) grind. None of these variables was controllable in this experiment. Nevertheless, as in the previous experiments, attribute differences did not, in turn, lead to significantly different acceptability ratings.

D. Experiment B-4. PBE Coffees Containing Extender E1

Results are displayed in Table 8. The full recipe (70 g) blends 1 and 2 with extender E1 were rated significantly darker in appearance than the half recipe amounts of the same blends with the extender. Mean rating levels of the 70 g recipes were equivalent to those obtained in the previous experiment (B-3) at the 45 g recipe range (PBE coffees 2 and 3). Thus, using a significantly greater increment of an extended coffee would not be expected to result in a significant increase in perceived darkness. The rating for the 35 g recipe of Blend 1 was the equivalent to the rating for PBE coffee 1 in the previous experiment which contained the same extender and was brewed at nearly the same recipe. Blend 2 at 35 g was rated significantly lighter in appearance than Blend 1 at the same recipe level. This was apparently due to the lighter roast color of Blend 2 as well as other sensory observations (flavor) that it was composed of different coffee beans.

Table 8. Preblended Extended Coffee Beverages Containing Extender E1

	Blend 1	Blend 1	Blend 2	Blend 2
Recipe (g)	70	35	70	35
Attributes*				
Appearance	7.8 ± 1.2a	6.4 ± 1.1b	7.2 ± 1.2a	4.7 ± 1.6c
Real Coffee Flavor	6.0 ± 2.2a	4.5 ± 1.8b	5.4 ± 2.3ab	3.6 ± 2.0c
Bitterness	6.2 ± 1.8a	5.0 ± 1.8bc	5.7 ± 1.8ab	4.3 ± 2.0c
Mouthfeel	5.2 ± 1.7a	4.2 ± 1.4b	5.0 ± 1.7a	3.5 ± 1.6c
Acceptability	4.8 ± 2.2a	4.8 ± 2.0a	4.9 ± 2.0a	3.8 ± 1.8a

* For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$). Coffee drinking patterns of 32 member panel (in %); black - 31.2; whitener - 28.2; sugar - 0; both 40.6.

For the taste-related attributes of coffee flavor and bitterness, the full recipes of each blend were rated significantly higher than the half-recipe beverages of the same blends. Again, apparently due to roasting and blend composition variation, Blend 1 was rated higher than Blend 2 at both recipe levels. (Note: the sourness attribute was eliminated from the Consumer Opinion Card for reasons outlined in Appendix A.)

Mouthfeel ratings reflected the twofold difference in recipe level; the 70 g recipe were perceived as significantly heavier in mouthfeel than the 35 g recipes. The contrast was greater with Blend 2 than with Blend 1, but both were perceived as slightly to moderately watery at the 35 g recipe level.

Ratings for acceptability were not significantly different among the four samples. Although ratings for coffee flavor and bitterness were lower for Blend 2 than for Blend 1 at the 70 g recipe, they suggested that the mild coffees, which probably made up Blend 2, were equally acceptable at this "full strength" recipe level. On the other hand, at the half-recipe level (35 g) of the same blend, considerable acceptability was lost, probably due to dilution of the mild flavor characteristics.

E. Experiment B-5. Two Commercial R&D Coffees without Extenders and Preblended with Extenders

Results are displayed in Table 9. In appearance, the extended coffees were perceived as equally dark, and both were significantly darker than the half recipe beverages prepared from the same R&G coffee blends without extenders. The full recipe Blend 2 beverage was rated significantly darker than the corresponding Blend 1 beverage, confirming preliminary observations of the R&G coffees before brewing. The differences could have been associated with variations in roast level, the caramel ingredient in the extender product, or both.

In this experiment, coffee aroma was an attribute investigated for inclusion on a final version of a Consumer Opinion Card. (See Appendix A for discussion.) Panelists found no significant differences among the four coffees. Possible reasons were: (1) the use of cream and sugar may have diminished the aroma impact and (2) because brewed coffee aromatics are volatile and quickly lost after brewing, a low level of aroma intensity remained, regardless of the original recipe levels. Differences in coffee flavor, however, were more pronounced. The blends without extender were rated higher in this attribute than the corresponding blends at half-recipe with extender; with Blend 2, the difference was significant. Both Blends 1 and 2 were rated significantly higher in bitterness than the corresponding half recipe blends with extender. There were no significant differences in mouthfeel among the beverages, due perhaps to a masking effect of the whitener. As to acceptability, there were no significant differences among the four beverages; however, the extended beverages were rated somewhat higher than the corresponding full recipe beverages without extender, evidently a reflection of the lower bitterness ratings of the former.

Table 9. Two R&G Coffee Blends without Extender Versus the Same Blends Premixed with Extenders*

	Blend 1 without Extender	Blend 1 with Extender E2	Blend 2 without Extender	Blend 2 with Extender E3
Recipe (g)	90	45	90	45
Extracted Solids (%)**	0.85	0.64	1.02	0.60
Attributes+				
Appearance	5.6 ± 1.4c	7.2 ± 1.4a	6.3 ± 1.2b	7.2 ± 1.2a
Coffee Aroma	5.1 ± 1.7a	5.4 ± 1.5a	5.6 ± 1.5a	5.2 ± 1.5a
Coffee Flavor	5.2 ± 1.8ab	4.7 ± 1.9b	5.8 ± 1.6a	4.6 ± 1.7b
Bitterness	5.3 ± 1.7a	4.0 ± 1.9b	5.9 ± 2.0a	4.2 ± 1.9b
Mouthfeel	5.2 ± 1.2a	5.0 ± 1.2a	5.6 ± 1.3a	5.1 ± 1.1a
Acceptability	5.5 ± 1.8a	5.7 ± 1.6a	5.2 ± 2.2a	5.5 ± 2.0a

* Coffees evaluated by panelists who used whitener and sugar. Number = 32.

** Average of two determinations.

+ For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$).

F. Experiment B-6. Institutional R&G Coffee Brand with and without Extender; Commercial PBE R&G Coffee

Results are given in Table 10. Both extended coffee beverages were rated significantly darker than the institutional brand, but not the troop-issue reference. This appeared due to lower-than-usual ratings for the extended coffees as well as to that segment of the panel using whitener (the instruction on the rating card to make the appearance rating prior to adding whitener had been eliminated. The PBE institutional brand was rated significantly lower in real coffee flavor than the same coffee without extender and the reference troop-issue beverage. The PBE coffee rated lower in the same attribute than the two full recipe coffees but the difference was not significant. It was noted that the PBE coffee was a finer grind than the other coffees and it was in very fresh condition prior to brewing. In bitterness, the troop-issue reference beverage was perceived as significantly more bitter than the other three beverages. The institutional brand without extender and the PBE beverage with extender E1, in turn, were significantly higher in bitterness than the institutional brand with extender. There were small differences in mouthfeel ratings among the beverages, and only the reference troop-issue beverage was significantly higher than the institutional brand with extender. Overall, this latter sample seemed to lose much more

Table 10. Selected R&G Coffees with and without Caramel-Base Extenders

	Troop-Issue without Extender	Institutional Brand without Extender	Institutional Brand with Extender E2	PBE R&G Coffee with Extender E1
Recipe (g)*	90 (Reference Level)	90 (Reference Level)	45 R&G + 2.25 E2	45
Attributes**				
Appearance	6.9 ± 1.1a	6.2 ± 1.3b	7.3 ± 1.2a	6.9 ± 1.2a
Real Coffee Flavor	5.5 ± 2.1a	5.4 ± 1.7a	3.9 ± 1.7b	5.0 ± 1.9a
Bitterness	6.6 ± 1.7a	5.0 ± 1.8b	3.7 ± 1.5c	4.8 ± 1.7b
Mouthfeel	5.4 ± 1.4a	5.0 ± 1.5ab	4.5 ± 1.2b	5.1 ± 1.2ab
Acceptability	4.4 ± 2.0b	5.6 ± 1.8a	5.2 ± 2.0a	5.7 ± 1.6a

* Extracted solids determination not run.

** Coffee drinking patterns of 32 member consumer panel (in %): black - 31.2; whitener only - 22.0; sugar only - 6.3; both - 37.5. For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$).

coffee identity (flavor, bitterness, mouthfeel) upon dilution than did the PBE product. Finally, on acceptability, the troop-issue reference beverage was rated significantly lower than the other three beverages. It was noted in this experiment that the coffee flavor rating was lower than in previous experiments with this lot of R&G coffee and the bitterness ratings were somewhat higher. The most probable explanation was that, at this point in the study, the troop-issue R&G was approximately four months over its rated shelflife at 21°C. Complaint samples of the same blend examined during the study revealed (1) that bitterness was the most common defect mentioned and (2) the coffee lots complained about were all overage.

G. Experiment B-7. Caramel-Based Extender Product with Modified Food Starch and Natural Mineral Ingredients

Results are given in Table 11. The beverage containing the previously-evaluated extender, E2, was perceived as significantly darker than all other samples. The beverage with the new extender, E4, was equivalent in darkness to the reference recipe beverage, very likely because a 30:1 coffee:extender ratio was used as recommended by the vendor. (The 20:1 ratio has been typical for extenders of this type.) As in previous experiments, the half recipe troop-issue beverage without extender was rated lowest.

Table 11. Comparative Evaluation of Two Caramel-Base Extender Products

	Troop-Issue Reference, No Extender	Troop-Issue with Extender E4	Troop-Issue with Extender E2	Troop-Issue No Extender
Recipe (g)	70	35 R&G + 1.2 E4	35 R&G + 1.8 E2	35
Extracted solids (%)*	1.05	0.60	0.63	0.53
Attributes**				
Appearance	5.9 ± 1.4b	6.2 ± 1.1b	7.1 ± 1.4a	3.2 ± 1.3c
Real Coffee Flavor	5.4 ± 1.7a	3.9 ± 1.5b	4.1 ± 1.9b	3.4 ± 1.8c
Bitterness	6.0 ± 1.7a	4.2 ± 1.7b	4.3 ± 2.0b	3.6 ± 1.8b
Mouthfeel	5.3 ± 1.1a	4.9 ± 1.3a	4.8 ± 1.1a	3.6 ± 1.4b
Acceptability	4.9 ± 1.8a	5.2 ± 1.8a	5.2 ± 2.0a	4.2 ± 2.0a

* Average of two determinations

** For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$). Use of whitener and sugar by 32-member panel was as follows (%): drank coffee black - 37.5; whitener - 12.5; sugar - 3.1; both - 46.9.

Rating patterns for flavor/taste attributes were the same as obtained in previous experiments. The troop-issue reference recipe beverage was rated significantly higher in real coffee flavor and bitterness than both extended beverages. Extended beverages were rated significantly higher in real coffee flavor than the half-recipe troop-issue beverage without extender.

Mouthfeel ratings were equivalent for the troop-issue reference and the extended beverages but were significantly lower for the half-recipe beverage without extender. Although there were no significant differences in acceptability, the half recipe beverage was lower rated than the extended beverages by approximately one scale point. It was clear from this experiment that extender E4, although it contained ingredients not included in the listed extender/enhancer product,[11] was virtually identical in sensory characteristics to the listed extender products. Thus, the claim made for the

[11]Coffee extender/enhancer. National Stock Number 01-088-5792, Federal Supply Catalog Stock List FSC Group 89-Subsistence, Defense Personnel Support Center, Philadelphia, PA.

quality of the beverage appeared unfounded. Regarding the claim of longer dwell time for water in the brew basket during brewing, it was observed that brewed coffee containing the new extender, E4, took the same amount of time to drop into the decanter as the coffee containing extender E2.

H. Experiment B-8. Four Holding-Time Studies of R&G Coffee without Extender versus Coffees Containing Extender E1

Results of the four experiments are displayed in Table 12.

Appearance. In studies a and b, in which R&G coffees with and without extender were tested, the extended beverages were perceived as significantly darker than the beverages without extender at both full- and half-recipe levels. There appeared to be a contrast effect in study b whereby the darkness of the full recipe extended beverage depressed ratings for the same troop-issue reference beverage presented in study a. This same effect was also evident in studies c and d, in which the coffee beverages at both recipe levels contained the extender product. The half-recipe with extender beverages rated considerably lower than was typical in study a and other experiments in this series. On the effects of hold time, in all cases but one (troop-issue without extender in study a), the held coffees were perceived to be darker after three hours holding than initially. This effect was significant for the half-recipe beverages in studies c and d. This result was probably due to heat stress over the three-hour period as well as to concentration by evaporation.

Real Coffee Flavor. Over the four studies, there were no significant decreases in this attribute after three hours for half-recipe extended beverages. There were consistent decreases between initial and three-hour hold samples for all full-recipe beverages. This effect was significant in two out of five cases, once with a beverage without extender (study a) and once with a beverage containing extender (study c). Base R&G coffee was troop-issue in both instances. Possibly, these effects were noted in full recipe beverages due to the higher initial levels of coffee flavor, which made detection of losses from heat stressing easier for consumer panelists. In the more dilute half-recipe beverages, less probability exists that flavor losses or changes would be detectable because of the low initial levels shown for these samples in Table 11.

Bitterness. With two exceptions, ratings for this attribute did not increase or decrease significantly after three hours' holding at either the full or half-recipe levels, with or without extender. The two exceptions were: (1) study a, in which the ratings for the troop-issue coffee beverage without extender decreased significantly after three hours' holding; and (2) study c, in which the rating for troop-issue R&G coffee with extender at the half recipe level increased significantly after three hours holding. It was evident that, contrary to claims made about the extender products, there was no general positive or negative effect on perception of bitterness at either recipe level after three hours holding.

Mouthfeel. Ratings for this attribute reflected the effect of recipe level as found in other experiments, but not the effect of hold time. One

Table 12. Brewed Coffee Holding Studies, Caramel-Based Extenders

a. Troop-Issue VS PBE R&G Coffee Blend 1

	Troop-Issue without Extender		PBE R&G Coffee with Extender E1	
Recipe (g)	70	70	35	35
Hold Time (hours)	0	3	0	3
Attributes Rated (N=32)*,+				
Appearance	6.0 ± 1.2b	5.7 ± 1.4b	6.6 ± 1.2a	7.0 ± 0.6a
Real Coffee Flavor	5.9 ± 1.2a	4.2 ± 1.9b	3.8 ± 1.9b	4.1 ± 1.7b
Bitterness	5.9 ± 1.7a	4.6 ± 1.7b	4.7 ± 1.8b	4.5 ± 1.5b
Mouthfeel	5.3 ± 1.0a	4.2 ± 1.2b	4.4 ± 1.1b	4.5 ± 1.1b
Acceptability	5.8 ± 1.8a	5.0 ± 1.9ab	4.3 ± 1.7b	5.0 ± 2.1ab

b. Troop-Issue VS PBE R&G Coffee Blend 1

	Troop-Issue without Extender		PBE R&G Coffee with Extender E1	
Recipe (g)	70	70	70	70
Hold Time (hours)	0	3	0	3
Extracted Solids (%)	0.87	0.89	0.98	0.99
Attributes Rated (N=32)*,+				
Appearance	4.4 ± 1.4c	5.4 ± 1.1b	7.6 ± 1.5a	7.9 ± 1.1a
Real Coffee Flavor	4.5 ± 2.0a	4.3 ± 1.4a	5.1 ± 2.3a	4.6 ± 2.5a
Bitterness	5.4 ± 1.9bc	4.8 ± 1.4c	6.4 ± 1.8a	6.1 ± 2.1ab
Mouthfeel	4.5 ± 1.3b	4.6 ± 1.0b	5.7 ± 1.6b	5.4 ± 1.8b
Acceptability	4.9 ± 1.8a	5.0 ± 1.6a	4.0 ± 2.1b	3.9 ± 2.1b

Table 12. Brewed Coffee Holding Studies, Caramel-Based Extenders (cont'd)

c. Troop-Issue Mixed with Extender E1**

Recipe (g)	70	70	35	35
Hold Time (hours)	0	3	0	3
Attributes Rated (N=32)*,+				
Appearance	7.2 ± 1.3a	7.4 ± 1.2a	4.8 ± 1.4c	6.1 ± 1.2b
Real Coffee Flavor	6.0 ± 1.5a	5.0 ± 1.7b	3.6 ± 1.6c	3.9 ± 1.6c
Bitterness	5.3 ± 1.4a	5.4 ± 1.6a	3.6 ± 1.5c	4.2 ± 1.6b
Mouthfeel	5.3 ± 1.2a	5.0 ± 1.4a	3.8 ± 1.1b	4.2 ± 1.2b
Acceptability	5.9 ± 1.7a	5.1 ± 1.7a	5.1 ± 2.0a	5.5 ± 1.7a

d. PBE R&G Coffee, Blend 2, at Two Recipe Levels

Recipe (g)	70	70	35	35
Hold Time (hours)	0	3	0	3
Attributes Rated (N=32)*,+				
Appearance	7.2 ± 1.0a	7.5 ± 1.1a	4.2 ± 1.4c	5.5 ± 1.4b
Real Coffee Flavor	5.3 ± 1.8a	5.0 ± 2.4a	3.4 ± 1.6b	3.2 ± 1.6b
Bitterness	5.7 ± 1.8a	6.3 ± 1.4a	3.7 ± 1.5b	3.8 ± 1.5b
Mouthfeel	5.4 ± 1.4a	5.5 ± 1.4a	3.6 ± 1.2b	3.9 ± 1.2b
Acceptability	5.2 ± 1.7a	4.5 ± 2.0a	4.5 ± 2.0a	4.5 ± 1.6a

* For each attribute, row means followed by different means are significantly different ($p \leq 0.05$)

** 22:1 R&G coffee:extender ratio, as recommended by supplier. PBE R&G coffees were said to contain the same ratio.

\+ Whitener and sugar usage by panels (in %), was as follows:

	Black	Whitener	Sugar	Whitener & Sugar
a.	28.1	37.5	-0-	34.4
b.	18.8	40.6	3.1	37.5
c.	25.0	28.1	3.1	43.8
d.	43.8	31.2	3.1	21.9

exception was study a, where the full recipe troop-issue beverage without extender was rated significantly lower after holding for three hours; this finding corresponded with the loss in coffee flavor over the same time period.

Acceptability. Ratings were significantly different in study a, between the full recipe troop-issue beverage without extender and the half-recipe PBE R&G coffee at zero hold time. In study b, the same PBE R&G coffee brewed at the full recipe rated significantly lower than the full recipe troop-issue coffee without extender. There was, in the latter study, no significant effect due to holding time; however, as suggested by previous experiments, there appeared to be an association between the bitterness and acceptability ratings.

In general, this series of studies indicated that the presence of an extender product in a brewing formula had little or no effect on the stability of a brewed coffee held hot for three hours, either in terms of sensory attribute ratings or acceptability, despite claims made about such benefits. R&G coffees of appropriate blend should be adequate as insurance against quality and acceptability losses, should brewed coffee be held longer than the one-half hour time recommended by AFRS guidelines. This statement is not to be construed as advice to hold brewed coffees longer than currently recommended. The holding problem in recent years has been mitigated by the wide adoption of 10-cup automatic brewers, which can produce coffee on demand in dining facilities.

Series C. Grains

A. Experiment C-1. Roasted and Ground Wheat (RGW) Substitute with R&G Coffee

Results are displayed in Table 13. RGW substituted coffee beverages were perceived as significantly darker in appearance than the commercial wheat substituted R&G coffee and the troop-issue reference beverage. In turn, the retail brand rated significantly higher than the troop-issue reference beverage. The apparent reason for the darker beverage appearance of the troop-issue/RGW blends was the dark color of the RGW ingredient compared to the troop-issue R&G coffee with which it was mixed. In this respect, the effect of using the RGW ingredient was similar to that of the caramel base extenders.

Although the RGW ingredient was enhanced with a coffee flavor and coffee oil, its combination with R&G coffee yielded a lower level of coffee flavor perception; at a 50 percent substitution level (sample 3), the rating was significantly lower than the reference beverage (sample 1) as was the rating for the retail coffee-wheat beverage (sample 4). Informal examination of samples 3 and 4 indicated a lack of coffee identity; flavor was primarily grainlike. It is likely that panelists' ratings reflected these low levels of coffeelike flavor.

Bitterness ratings for both RGW substituted beverages were significantly lower than the reference beverage, as were the sourness attribute ratings. The retail brand (sample 4) was also rated lower than the reference beverage.

Table 13. Roasted & Ground Wheat (RGW) Substitute with R&G Coffee

Beverage	1	2	3	4
Recipe (g)	Troop-Issue 90(100%)	TI-60(66.7%) RGW-30(33.3%)	TI-45(50%) RGW-45(50%)	Retail Brand 90
Extracted solids(%)*	1.05	1.05	0.98	1.55
Attributes Rated, N=32**				
Appearance (Before adding cream)	6.3 ± 1.4c	8.1 ± 1.0a	8.3 ± 0.7a	6.8 ± 1.3b
Strength of Coffee Flavor	6.2 ± 2.0a	5.6 ± 2.2ab	5.3 ± 2.0b	5.4 ± 2.1b
Strength of Bitterness	6.3 ± 1.6a	5.2 ± 2.1bc	4.8 ± 2.0c	5.8 ± 1.9ab
Strength of Sourness	5.3 ± 2.0a	4.4 ± 1.9b	4.6 ± 2.4b	4.7 ± 2.4b
Mouthfeel	5.4 ± 1.6a	4.9 ± 1.4a	5.1 ± 1.6a	5.1 ± 1.5a
Acceptability	5.2 ± 2.4a	5.2 ± 2.3a	4.7 ± 2.0a	4.7 ± 2.0a

* Average of two determinations

** Panelists were consumers who drank coffee black. For each attribute, row means followed by different letters are significantly different, $p \leq 0.05$

No significant differences were found among samples in mouthfeel. Samples 1, 2 and 3 were equivalent in extracted solids yield, but the commercial sample (4) was about 50 percent higher, possibly because of higher extraction levels from the wheat ingredient used in that product. This, however, did not affect the sensory perception of mouthfeel.

No significant differences occurred in acceptability among the beverages, although samples 3 and 4 were rated lower. Indications were, that on the basis of acceptability alone, a RGW ingredient might be substituted for coffee up to 50 percent. Higher levels would not be warranted, if the intent is for R&G coffee to be the predominant ingredient for labeling purposes.

B. Experiment C-2. Malted and Unmalted Barleys

Experimental results are given in Table 14. Malted barley substituted coffee beverages were rated significantly darker than the unmalted barley substituted beverages at both substitution levels. The troop-issue reference

beverage was rated equivalent in darkness to the unmalted barley substituted beverages. Preliminary observation of the unground whole roasted malted grains revealed a considerable variation in color development. Some grains were brown, others were charred; the composite ground sample was dark brown. The unmalted grains were more uniform in roast color development and approximated the color of troop-issue coffee when ground.

Table 14. Troop-Issue R&G Coffee Combined with Malted and Unmalted Barleys

Beverage	1	2	3	4	5
Recipe (g)	90, Troop-Issue (TI) (reference)	72 TI (80%) 18 Malted (20%)	54 TI (60%) 36 Malted (40%)	72 TI (80%) 18 Unmalted (20%)	54 TI (60%) 36 Unmalted (40%)
Extracted solids(%)	1.06	1.15	1.37	1.06	1.08
Attributes Rated, N=32*					
Appearance	6.1 ± 1.1c	6.9 ± 1.1b	7.4 ± 1.2a	5.8 ± 1.4c	6.0 ± 1.6c
Coffee Aroma	5.2 ± 1.6a	5.2 ± 1.4a	5.1 ± 1.9a	5.4 ± 1.7a	4.6 ± 1.7a
Coffee Flavor	5.6 ± 1.7a	5.6 ± 1.6a	5.5 ± 1.5a	5.4 ± 2.0a	5.0 ± 1.8a
Bitterness	5.9 ± 1.6a	5.8 ± 2.0a	5.6 ± 2.0a	5.4 ± 1.9a	4.5 ± 2.1b
Mouthfeel	5.5 ± 1.1a	5.5 ± 1.0a	5.5 ± 1.2a	5.3 ± 1.2a	5.1 ± 1.5a
Acceptability	5.1 ± 1.6a	4.5 ± 1.8a	4.4 ± 2.1a	4.9 ± 1.8a	4.7 ± 1.8a

* For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$). Consumer panelists were randomly selected coffee drinkers. Optional whitener and sugar were provided for those wishing to use them.

All beverage samples were equivalent, in terms of statistical significance, in coffee aroma and flavor. Mean ratings were lower by about one scalepoint for the troop-issue reference beverage compared to ratings obtained when caramel base extenders were evaluated. Informal observations indicated the 20 percent barley-substituted brews were more like coffee than like grain, and the 40 percent barley-substituted brews appeared more roast grainlike with a coffee aftertaste. Unmalted barley at a 40 percent substitution level (Beverage 5) was rated significantly lower in bitterness

than all other beverages. Although coffee-related bitterness appeared less in all the barley-substituted beverages in informal sensory examinations, a burntness associated with the roasted barley was also noted. This characteristic may have been interpreted by consumer panelists as a bitter taste.

There were no significant differences among the samples in mouthfeel, not surprising since the extracted solids in the samples were roughly equivalent. Finally, acceptability ratings were not significantly different. The two barley types at the two substitution levels did not decrease acceptability significantly compared to the reference beverage.

In other observations, it was noted during brewing, as the extract flowed from the brew basket into the decanter, that a foamy "head" formed. In beverages containing the malted barley, the foam collapsed rapidly. However, the "head" forming over coffees containing the unmalted barley was creamy white and more stable; collapse was considerably slower than in the beverages brewed with malted barley.

C. Experiment C-3. Roasted and Ground Pearled Barley Substitute

Results are displayed in Table 15. As barley level was increased from 0 to 75 percent in the recipes, appearance of the brews was rated increasingly darker. The 100 percent barley brew, however, was rated significantly lower in darkness than the brew prepared from the 75 percent barley recipe (beverage 4) but significantly higher than the 100 percent coffee beverage. Up to a 50 percent barley substitution level, no significant change in coffee flavor ratings occurred; at 75 percent, a nonsignificant decrease was noted and the 100 percent barley beverage was rated significantly lower in the attribute than all other samples. Surprisingly, the mean coffee flavor rating for the 100 percent troop-issue reference beverage was more than one scalepoint lower than that typically obtained in similar experiments. Ratings for the bitterness attribute did not drop significantly until 100 percent barley was substituted for coffee; as in the previous experiment, panelists may have interpreted the roast barley characteristics as bitter in taste. With the mouthfeel attribute, the 100 percent barley beverage was rated as "slightly watery" on the scale while the other beverages rated approximately "intermediate."

Acceptability of the 75 percent barley substituted beverage was significantly lower than the 100 percent coffee and the 50-50 coffee-barley beverages. This followed the rating pattern for the drop in the real coffee flavor attribute after the 50-50 substitution level was reached. It is emphasized here that identity of the beverage samples as not divulged to panelists. Thus, even the 100 percent barley beverage was evaluated under the name "coffee."

D. Experiment C-4. Medium and Dark Roasted and Ground Whole Grain Barleys (RGB)

Results of the separate experiments conducted on the medium and dark roast barleys are contained in Table 16.

Table 15. Roasted and Ground Pearled Barley (PB) Combined with Troop-Issue (TI) R&G Coffee

Beverage	1	2	3	4	5
Recipe (g)	90.0 TI (100%) 0 PB (0%)	67.5 TI (75%) 22.5 PB (25%)	45 TI (50%) 45 PB (50%)	22.5 TI (25%) 67.5 PB (75%)	0 TI (0%) 90 PB (100%)
Extracted solids(%)	1.12	1.36	1.62	1.88	1.66
Attributes Rated, N=40*					
Appearance	6.2 ± 1.1c	6.5 ± 1.3bc	7.0 ± 1.3ab	7.4 ± 1.2a	6.8 ± 1.5b
Real Coffee Flavor	4.8 ± 1.7a	4.5 ± 1.6a	4.8 ± 1.6a	4.1 ± 1.9a	2.8 ± 1.7b
Bitterness	5.5 ± 1.6a	5.5 ± 1.6a	5.4 ± 1.9a	4.9 ± 2.2ab	4.4 ± 2.5b
Mouthfeel	5.2 ± 1.2a	4.7 ± 1.2ab	4.8 ± 1.1ab	5.0 ± 1.6a	4.2 ± 1.8a
Acceptability	4.8 ± 1.9a	4.3 ± 1.6ab	4.6 ± 1.8a	3.8 ± 1.8b	3.0 ± 1.7c

* Row means followed by different letters are significantly different, $p \leq 0.05$. Consumer panelists were randomly selected coffee drinkers who reported evaluating samples as follows (%): black - 42.5; whitener - 20; sugar - 5; whitener and sugar - 32.5.

Table 16. Troop-Issue (TI) R&G Coffee Combined with R&G Medium and Dark Roast Whole Grain Unmalted Barleys (RGB)

Beverage	1	2	Medium Roast Series 3	4	5
Recipe (g)	90 TI (100%) 0 RGB (0%)	67.5 TI (75%) 22.5 RGB (25%)	45 TI (50%) 45 RGB (50%)	22.5 TI (25%) 67.5 RGB (75%)	0 TI (0%) 90 RGB (100%)
Extracted solids(%)	1.14	1.56	1.91	1.69	1.88
Attributes Rated, N=40*,**					
Appearance	5.8 ± 1.5b	7.0 ± 1.3a	7.5 ± 1.3a	7.6 ± 1.0a	7.6 ± 1.3a
Real Coffee Flavor	4.5 ± 1.9a	5.1 ± 2.0a	4.3 ± 2.2a	3.1 ± 2.1b	2.7 ± 1.8b
Bitterness	5.5 ± 2.1a	6.0 ± 1.8a	5.4 ± 2.2a	4.4 ± 2.1a	4.5 ± 2.3b
Mouthfeel	4.8 ± 1.2ab	4.9 ± 1.4a	4.8 ± 1.5ab	4.7 ± 1.6ab	4.2 ± 1.5b
Acceptability	4.5 ± 2.0a	4.8 ± 2.1a	4.1 ± 1.8a	4.0 ± 2.0a	3.1 ± 1.8b

Beverage	1	2	Dark Roast Series 3	4	5
Recipe (g)	90 TI (100%) 0 RGB (0%)	67.5 TI (75%) 22.5 RGB (25%)	45 TI (50%) 45 RGB (50%)	22.5 TI (25%) 67.5 RGB (75%)	0 TI (0%) 90 RGB (100%)
Extracted solids(%)	1.10	1.62	1.91	1.82	1.77
Attributes Rated, N=40+					
Appearance	5.4 ± 1.5c	7.4 ± 1.1b	7.9 ± 1.1a	8.2 ± 1.0a	8.4 ± 0.6a
Real Coffee Flavor	5.1 ± 2.0a	5.0 ± 1.6a	5.3 ± 1.7a	4.4 ± 2.4ab	4.0 ± 2.5b
Bitterness	5.9 ± 1.8a	5.2 ± 1.7a	5.9 ± 1.8a	5.6 ± 2.0a	5.4 ± 2.3a
Mouthfeel	5.2 ± 1.1a	5.2 ± 1.2a	5.4 ± 1.3a	5.4 ± 1.6a	5.5 ± 1.4a
Acceptability	4.6 ± 2.2a	4.7 ± 1.9a	4.3 ± 1.9a	3.9 ± 2.1a	2.9 ± 1.7b

* For each attribute, row means followed by different letters are significantly different, $p \leq 0.05$.

** For this series, randomly selected coffee drinkers who reported evaluating samples as follows (%): black - 20; whitener - 35; sugar - 0, whitener and sugar - 45.

\+ For this series, randomly selected coffee drinkers who reported evaluating samples as follows (%): black - 32.5; whitener - 27.5; sugar - 2.5; whitener and sugar - 37.5.

Medium Roast Series. Although preliminary examination of the ground grain and a "barley brew" indicated a close color match to the troop-issue R&G coffee and brew, consumer panelists rated all beverages containing the RGB substitute significantly darker than the troop-issue reference beverage. One reason may have been the proportionally higher level of extraction from the barley ingredient than from the R&G coffee, as suggested by the extracted solids analyses.

Real coffee flavor ratings were not significantly lower until the 50 percent substitution level was reached. The same outcome pertained to bitterness ratings. Little variation in mouthfeel was seen, but the 100 percent barley tended toward a "slightly watery" character compared to the other beverages which approached the "intermediate" scale point. Finally, a significant drop in acceptability occurred when the 100 percent barley substitution level was reached. As in experiment C-3 preceeding, all beverages were evaluated under the name "coffee."

Dark Roast Series. As in the medium roast series, appearance of beverages at all levels of barley substitution was rated significantly darker than the troop-issue reference beverage. In turn, the beverage at the 50 percent level was rated significantly darker than the 25 percent substitution level. All dark roast RGB substitution levels were rated darker than the corresponding medium roast substitution levels. Mean values approximated those typically obtained for caramel-base extender products, and confirmed preliminary observations made on whole and ground barley grains and beverages, i.e., that there was a perceptible difference in appearance between the medium and dark roast level grains.

As with the medium roast series, real coffee flavor showed no notable and/or significant decrease until the 50 percent barley substitution level was exceeded. Even so, the dark roast substituted beverages were rated higher in coffee-like flavor identity than each corresponding level of medium roast RGB substitution. At the same time, there were no significant differences among the beverages in levels of perceived bitterness. Evidently, panelists interpreted the higher (darker) roast level of beverages brewed from the dark roast barley as being more bitter in taste than beverages brewed from the medium roast barley. Mouthfeel of the dark roast barley-substituted beverages was rated somewhat higher than the medium roast-substituted beverages, and no significant differences were found in ratings among any levels of substitution. Acceptability levels were essentially the same among the dark roast barley beverages as the medium roast beverages, and no significant differences were found.

In general, the findings suggested that, on the basis of attribute ratings other than acceptability, particularly real coffee flavor, the dark roast RGB might be the most appropriate substitute for R&G coffee at levels up to 50 percent; substitution levels above 50 percent would not appear practical because, as with the wheat substitute, the beverage would no longer be predominantly coffee.

Series D. Miscellaneous Extenders

A. Experiment D-1. Commercial Coffee Extender (CE)

Results are presented in Table 17. In appearance, the beverages brewed with the CE were rated equivalent in darkness to the troop-issue reference beverage. The half-formula troop-issue beverage without CE (No. 2) was rated significantly lighter. These results suggested that the CE product functioned either to add color to the brewed beverages (no coloring material was declared on the label) or to extract more color (caramel) from the R&G coffee).

Strength of coffee flavor of beverages with CE was rated significantly less than the troop-issue reference beverage, and in turn, the half-recipe troop issue beverage without CE was rated significantly lower than those

Table 17. Commercial Extender (CE) Combined with Troop-Issue (TI) R&G Coffee

Beverage	1	2	3	4
Recipe (g)	90 TI 0 CE (reference)	45 TI 0 CE	54 TI 1.8 CE	45 TI 2.1 CE
Extracted solids(%)	1.05	0.52	0.71	0.61
Attributes Rated, N=32*				
Appearance (Before adding cream)	7.0 ± 1.1a	3.7 ± 1.6b	7.5 ± 1.3a	7.4 ± 1.2a
Strength of Coffee Flavor	6.9 ± 1.4a	4.6 ± 1.7c	5.7 ± 1.8b	5.6 ± 2.1b
Strength of Bitterness	6.6 ± 1.7a	4.8 ± 1.7b	5.2 ± 2.1b	5.4 ± 2.0b
Strength of Sourness	5.4 ± 2.2a	3.9 ± 2.0b	4.6 ± 2.0b	4.3 ± 2.1b
Mouthfeel	5.9 ± 1.3a	4.0 ± 1.4c	5.3 ± 1.4b	5.2 ± 1.3b
Overall Acceptability	5.3 ± 1.8a	4.5 ± 2.0a	4.9 ± 2.0a	4.5 ± 1.9a

* Coffees served black to consumer panelists who drank coffee this way. For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$).

brewed with the CE product. A similar pattern of ratings was observed for bitterness, although the half-recipe beverage was not significantly lower. Sourness rating patterns followed those of flavor strength but were at lower levels. Mouthfeel ratings seemed to reflect the flavor/taste attribute ratings as well as the extracted solids determinations for the samples. Finally, acceptability levels were not significantly different among the samples and tended to be lower than the reference sample for the beverages brewed with the CE product as well as for the half-recipe troop-issue beverage.

Other Observations. The CE product prolonged brewing time by slowing the rate at which coffee extract flowed through the brewer paper filter into the decanter. Average flow time for the automatic brewer used in these experiments was four minutes. Brewing of R&G coffees mixed with the CE product required nearly eight minutes. This would be a disadvantage in operations utilizing these brewers during periods of high coffee demand.

Informal examination of the beverages brewed with the CE product (beverage 3 and 4) indicated the following descriptions: an overall "artificial" coffee character, a nonaromatic "instant coffee" character, and noncoffee off characteristics. These changes in brewed beverage characteristics may have been reasons for the significantly lower flavor strengths than the reference beverage as indicated above.

There were no significant differences in consumer ratings for any attribute between a 40 percent reduction (beverage 3) and a 50 percent reduction (beverage 4) in R&G coffee. Thus, either reduction level could be used, but neither one, from the evidence presented here would, in conjunction with the CE product, produce a coffee beverage equivalent in quality characteristics to the reference beverage. The extracted solid levels seemed to be in proportion to the amount of R&G coffee used in the recipe; the marginal increases in solids (compare half recipe beverages 2 and 4) were likely contributed by the extender product itself.

B. Experiment D-2. Roasted and Ground Coffee with Instant Coffee Powder as an Extender

Results are displayed in Table 18. Perceived darkness or lightness (appearance) of the beverages was related to extracted solids levels of the beverages and not to the presence or absence of instant coffee in the recipe; beverages 1 and 2 were rated significantly darker than beverages 3 and 4. Clearly, instant coffee when used to replace R&G coffee was not as potent a colorant as the caramel base extenders.

Real coffee flavor ratings for beverages 1 and 2 were not significantly different from each other, but were significantly higher than beverages 3 and 4. In turn, beverage 3 without instant coffee was rated significantly higher than beverage 4 with instant coffee in the recipe; it should be noted that both ratings were in the slightly to moderately weak range. Replacement of R&G coffee with instant coffee solids at the reference recipe level also

Table 18. Commercial Brand R&G Coffee Extended with Instant Coffee (IC)

Beverage	1	2	3	4
Recipe (g)	90 R&G 0 IC	45 R&G 9.0 IC	45 R&G 0 IC	22.5 R&G 4.5 IC
Extracted solids(%)	1.07	1.08	0.55	0.55
Attributes Rated, N=32*				
Appearance	7.0 ± 1.1a	6.6 ± 1.1a	4.7 ± 1.6b	4.6 ± 1.8b
Real Coffee Flavor	6.0 ± 1.4a	5.6 ± 1.3a	3.9 ± 1.6b	3.1 ± 1.2c
Bitterness	5.9 ± 1.8a	5.6 ± 1.7ab	4.8 ± 1.8b	3.7 ± 1.6c
Mouthfeel	5.8 ± 1.2a	5.2 ± 1.0b	4.4 ± 1.3c	4.0 ± 1.4c
Acceptability	5.2 ± 1.9ab	5.9 ± 1.8a	5.1 ± 1.6ab	4.6 ± 1.5b

* For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$). Consumer panelists were randomly selected coffee drinkers who reported evaluating the samples as follows (%): black - 40%; whitener - 25.0; sugar 9.3, whitener and sugar - 25.0.

resulted in a loss of coffee flavor strength. Similar rating patterns were seen for the bitterness attribute; there was a reduction in perceived bitterness when instant coffee was used at both extracted solids levels. The mouthfeel attribute rating for beverage 1 was significantly higher than for beverage 2. There was a trend toward the watery side of the scale when instant coffee was used at both high and low solids levels. In informal sensory assessments, it was noted that beverages with instant coffee in the recipe were less aromatic than those brewed only from R&G coffee. Beverages with instant coffee tended to take on the overall character of instant coffee itself. Possibly, this was a reason for the apparent losses in coffee flavor strength as well as in mouthfeel.

In acceptability, the lower extracted solids coffees were rated lower than high solids coffees. The difference was significant only between high and low solids beverages containing instant coffee. Based on acceptability alone, instant coffee might be a viable ingredient for brewed coffee recipes, should a sufficient price differential exist between it and R&G coffee and if standard recipe equivalents are used. However, the evidence here suggested it would not function to "extend" R&G coffee at the lower solids level recipes by maintaining or increasing levels of flavor/taste characteristics.

C. Experiment D-3. Roasted and Ground Coffee with Chicory

Results are given in Table 19. The appearance of beverages prepared from the coffee-chicory blends was rated significantly darker than those brewed from the troop-issue reference and the commercial expanded R&G coffees. Possibly, the chicory ingredient contributed the additional color, since the extracted solids levels of these beverages were considerably higher than those of the all-coffee beverages, whether the recipe was 60 or 90 g.

Ratings for the flavor/taste attributes of real coffee flavor and bitterness did not differ significantly among the samples. This seemed surprising, inasmuch as informal preliminary examinations of the beverages suggested considerable differences between those with and without chicory. Even though chicory was observed to dominate flavor of the coffee-chicory beverages, consumer panelists rated them equivalent to the all-coffee beverages in the coffeelike characteristics. There were no significant differences among the samples in mouthfeel; the beverages with chicory were rated marginally more heavy than the all-coffee beverages.

Table 19. R&G Coffees with and without Chicory

Beverage	TI Reference*	Comm'l Expanded*	Chicory, Brand 1	Chicory, Brand 2
Recipe (g)	90	60	60	90
Extracted solids(%)	1.05	0.75	1.42	1.39
Attributes Rated, N=32**				
Appearance	6.3 ± 1.3b	6.8 ± 1.4b	7.8 ± 1.0a	7.4 ± 1.0a
Real Coffee Flavor	5.1 ± 2.0a	5.8 ± 2.0a	5.1 ± 1.9a	5.0 ± 2.1a
Bitterness	5.7 ± 1.8a	6.0 ± 2.2a	5.5 ± 1.7a	6.1 ± 2.1a
Mouthfeel	5.1 ± 1.4a	5.3 ± 1.6a	5.5 ± 1.6a	5.5 ± 1.6a
Acceptability	4.5 ± 2.0a	4.5 ± 2.3a	4.4 ± 2.0a	3.7 ± 2.1a

* Moisture analyses of R&G coffees: TI reference (1) - 2.67%; comm'l expanded (2) - 1.94%.

** For each attribute, row means followed by different letters are significantly different ($p \leq 0.05$). Consumer panelists were randomly selected coffee drinkers who reported evaluating the samples as follows (%): black - 53.1; whitener - 12.5; sugar - 0; whitener and sugar - 34.4.

Finally, no significant differences were found in acceptability. Ratings for the all-coffee beverages were lower than those typically obtained in other experiments. The acceptability rating for the chicory brand 2 beverage suggested that, although consumers considered it coffee-like to a degree, it was somewhat unacceptable.

Series E. Robusta Coffee Beans

Step 1 Experiments. Results are displayed in Table 20. In general, rating patterns were similar for both the Ivory Coast and Ugandan coffees used to replace the troop-issue R&G coffee. In both experiments, the beverage prepared from the 100 percent Robusta coffee was rated significantly darker than the other two replacement levels and the troop-issue reference beverage. Blends containing the Ugandan coffee at 10 and 25 percent levels were, in turn, rated significantly darker than the troop-issue reference beverage, although mean values only tended toward the "slightly dark" category.

Real coffee flavor attribute ratings were not significantly different among the beverages in either the Ivory Coast or Ugandan series. Mean values for the troop-issue reference beverages in both tests were atypically low. It seemed surprising that consumer panelists would rate all samples in both tests equivalent in real coffee flavor, in view of the considerable flavor differences among the samples observed in informal descriptive evaluations. Beverages brewed from R&G coffees containing 10 percent Robusta levels seemed to have a "just noticeable" change in flavor. Those at 25 percent had dominant Robusta flavor characteristics such as "musty" and "tarry" that masked the characteristics of the troop-issue blend. At a 100 percent Robusta levels, the general character of the beverages were not appreciably different from the 25 percent substitution levels.

Bitterness of beverages containing Ivory Coast coffees increased with the Robusta level; this increase did not occur with the Ugandan Robustas. There were no significant differences in mouthfeel in either experiment.

Acceptability of the 100 percent Ivory Coast beverage was significantly lower than the troop-issue reference and 10 percent substitution beverage. There were no significant differences in acceptability among the Ugandan series beverages, although the 100 percent Robusta beverage was lowest rated.

Before conducting these experiments, it was anticipated that differences in quality attribute perceptions and acceptability would be dramatic as Robusta levels were increased because of consumer unfamiliarity with their flavor characteristics. Such was not the case. Data suggested that up to 25 percent Robustas might be used without adverse consequences to quality-related characteristics or acceptability.

Other Observations. The provided samples of roasted Ivory Coast coffee beans were uniform in size and roast color development. The Ugandan roasted beans, however, were characterized by lack of uniformity in color - these were numerous overroasted black beans - and the presence of extraneous material

Table 20. Two Medium Roast African Robusta Coffees Combined with Troop-Issue Blend (Step 1)

Beverage	Ivory Coast (IC) 1	2	3	4
Recipe (g) (% IC)	70 TI 0 IC (0) (Reference)	63 TI 7.0 IC (10)	52.5 TI 17.5 IC (25)	0 TI 70 IC (100)
Extracted solids(%)	0.85	0.81	0.81	0.87
Attributes Rated (N=32)*,**				
Appearance	5.3 ± 1.2b	5.3 ± 1.3b	5.3 ± 1.3b	6.8 ± 1.2a
Real Coffee Flavor	4.2 ± 1.5a	4.8 ± 1.6a	3.9 ± 1.4a	4.1 ± 2.2a
Bitterness	4.4 ± 1.7b	4.5 ± 1.8b	5.1 ± 2.0ab	5.7 ± 2.0a
Mouthfeel	4.7 ± 1.1a	4.5 ± 1.2a	4.6 ± 1.3a	5.3 ± 1.4a
Acceptability	5.1 ± 1.8a	5.3 ± 1.7a	4.6 ± 1.7ab	4.0 ± 2.1b

Beverage	Ugandan (UG) 1	2	3	4
Recipe (g) (% UG)	70 TI 0 UG (0) (Reference)	63 TI 7.0 UG (10)	52.5 TI 17.5 UG (25)	0 TI 70 UG (100)
Extracted solids(%)	0.88	0.87	0.84	0.80
Attributes Rated (N=32)*,**				
Appearance	5.2 ± 1.0c	5.7 ± 1.3b	5.8 ± 1.0b	6.7 ± 1.2a
Real Coffee Flavor	4.6 ± 1.4a	4.5 ± 1.7a	4.5 ± 1.6a	4.4 ± 1.8a
Bitterness	5.7 ± 1.6a	5.8 ± 1.2a	5.3 ± 1.7a	5.5 ± 2.0a
Mouthfeel	5.0 ± 1.0a	4.8 ± 1.0a	4.8 ± 1.0a	5.1 ± 1.0a
Acceptability	4.8 ± 1.4a	4.7 ± 1.6a	5.3 ± 1.7a	4.4 ± 1.7a

* For each attribute, row means followed by different letters are significantly different, $p \leq 0.05$.

** Consumer panelists reported the following usage of whitener and sugar for the Ivory Coast series (%): black - 25; whitener - 28.1; whitener and sugar - 40.6; for the Ugandan series (%): black 40; whitener - 12.5; sugar - 6.3; whitener and sugar - 40.6.

such as stones. Conversations with coffee industry technical people indicated that the Ivory Coast sources were reputed to deliver consistently better quality beans. Therefore, this source of Robusta coffees was selected for further experiments in blending and field testing.

Step 2 Experiments. Pre- and post-roast blends with Ivory Coast Robusta Coffee. Data for two experiments are presented in Table 21. In the pre-roast blend series, no significant differences were found among samples for any of the five attributes rated. In the post-roast blend series, significant differences occurred in ratings for appearance and acceptability. The acceptability rating for beverage 3 (30 percent IC) was significantly higher than for beverage 4 (100 percent IC). For appearance, the 30 and 100 percent Robusta blends were significantly darker than the reference blend.

Differences in quality-related attributes and acceptability between pre- and post-roast blending for corresponding samples and attributes appeared inconsequential. Acceptability of post-roast blends was marginally higher than for pre-roast blends. Based on these data, it was evident that, in terms of consumer responses, blending practice had little effect. Inasmuch as pre-roast blending is the current practice of contractors producing R&G coffee for the military, there would be no reason for a change if alternative blends were adopted. Finally, it was clear that up to 30 percent Robusta coffees could be used in combination with a different (50:50) ratio of the coffees currently used in the military blend without an adverse effect on perception of quality-related attributes or acceptability. Accordingly, this substitution level was selected for a subsequent field test.

Field Evaluation of Coffee Extenders and Alternative Blends

A. Fort Campbell, KY

Garrison evaluation of R&G coffee preblended with caramel-base extender product. The total responses collected were 111 on the troop-issue coffee prepared according to normal practice in each dining facility and 218 on the procured R&G coffee preblended with the extender product at one-half the normal recipe. Numbers of responses were unequal, primarily because some of the participating facilities did not observe test plan instructions to alternate between the two coffees over the four days. It was noted that four of the seven facilities routinely used one-half the coffee or less in their recipes than called for on AFRS recipe cards. The other three used from three-fourths to the full recipe amount. Because of this variation, consumer responses were cross-tabulated according to these brackets in two ways: (1) across both coffees by recipe grouping and (2) each coffee by recipe group. Results are displayed in Table 22.

In general, attribute rating levels across all dining facilities surveyed were comparable to those obtained in laboratory evaluations of similar coffee products. The appearance of the extended coffee was not, however, rated significantly darker than the troop-issue beverage. This result may be because nearly two thirds of the cross-tabulated responses were obtained in dining facilities using one third to one half the recommend recipe amount of

Table 21. R&G Coffee Pre- and Post-Roast Coffee Blended with Ivory Coast Robusta Coffees (Step 2)

Beverage*	Pre-Roast Blend Series 1	2	3	4
Blends,%**	70 BR 30 BR 0 IC (Reference)	40 BR 40 CO 20 IC	35 BR 35 CO 30 IC	0 BR 0 CO 100 IC
Extracted solids(%)	0.95	0.76	0.74	0.87
Attributes Rated, N=32+,#				
Appearance	5.8 ± 1.2	5.2 ± 1.2	5.8 + 1.4	5.6 ± 1.2
Real Coffee Flavor	4.7 ± 2.0	4.4 ± 1.9	4.9 ± 1.6	4.2 ± 2.1
Bitterness	5.8 ± 1.5	5.1 ± 1.8	4.9 ± 1.6	5.7 ± 1.8
Mouthfeel	4.8 ± 1.7	4.4 ± 1.2	5.1 ± 1.4	4.7 ± 1.6
Acceptability	4.6 ± 1.9	4.8 ± 1.8	4.9 ± 2.0	4.3 ± 2.1

Beverage*	Post-Roast Blend Series 1	2	3	4
Blends,%**	70 BR 30 BR 0 IC (Reference)	40 BR 40 CO 20 IC	35 BR 35 CO 30 IC	0 BR 0 CO 100 IC
Extracted solids(%)	0.68	0.68	1.02	0.89
Attributes Rated (N=32)++,##				
Appearance	5.4 ± 1.2b	5.7 ± 1.2ab	6.2 + 1.2a	6.1 ± 1.4a
Real Coffee Flavor	4.3 ± 1.4a	4.3 ± 1.6a	4.7 ± 1.6a	4.6 ± 2.1a
Bitterness	4.8 ± 1.4a	4.8 ± 1.5a	5.1 ± 1.2a	5.5 ± 1.8a
Mouthfeel	4.5 ± 1.0a	4.6 ± 1.1a	4.9 ± 1.1a	4.8 ± 1.5a
Acceptability	5.2 ± 1.2ab	5.1 ± 1.7ab	5.5 ± 1.4a	4.5 ± 1.8b

* Recipe for all beverages was 70 g.
** BR = Brazilian; CO = Colombian; IC = Ivory Coast.
\+ No significant differences among samples for any attribute.
++ For each attribute, row means followed by different letters are significantly different, $p \leq 0.05$.
\# Consumer panelists reported the following usage of whitener and sugar (%): black - 18.8; whitener - 31.2; sugar - 9.4; whitener + sugar - 40.6.
Consumer panelists reported the following usage of whitener and sugar (%): black -31.2, whitener - 31.2; sugar - 0; whitener + sugar - 37.6.

Table 22. Fort Campbell, KY Survey, Troop-Issue and Extended Coffees

	All Dining Facilities*		Grouped by Recipe	
Recipe (g)	Full	One-half	1/3 to 1/2 AFRS	3/4 to Full AFRS
Coffee Surveyed	Troop-Issue	Preblended Extended	- Across Both Coffees -	
Number of Responses	111	218	184	115
Attributes Rated				
Appearance	6.0 ± 1.6	6.1 ± 1.4	6.0 ± 1.5+	6.3 ± 1.5
Real Coffee Flavor	5.3 ± 1.5**	4.9 ± 1.5	5.0 ± 1.5	5.0 ± 1.6
Bitterness	5.0 ± 1.8	4.6 ± 1.7	4.8 ± 1.8	4.5 ± 1.8
Mouthfeel	4.8 ± 1.4	4.7 ± 1.3	4.7 ± 1.4	4.8 ± 1.4
Acceptability	6.3 ± 2.0	6.2 ± 1.9	6.2 ± 2.0	6.2 ± 1.9

	Each Coffee by Recipe Group			
Recipe Group	1/3 to 1/2 AFRS Card (4 facilities)		3/4 to Full AFRS Card (3 facilities)	
Coffee Surveyed	Troop-Issue	Extended	Troop-Issue	Extended
Number of Responses	79	105	32	83
Attributes Rated++				
Appearance	5.9	6.1	6.3	6.3
Real Coffee Flavor	5.3	4.8	5.2	4.9
Bitterness	4.9	4.7	5.1	4.3
Mouthfeel	4.9	4.6	4.6	4.8
Acceptability	6.2	6.1	6.3	6.2

* Whitener and sugar usage data not tabulated, because it was inadvertently purged from computer file.

** Significantly different in t-test, p=0.02. Differences between coffees for other attributes were not significant.

+ No significant differences between coffees for any attribute. Excluded were 30 responses from a field exercise in which recipe and brewing method were unknown.

++ Weighted mean values hand computed from sums ratings for each facility. Sum of squares rating statistic not available from cross-tabulation program. Therefore, standard deviation could not be hand computed.

R&G coffee. This fact means that one sixth to one fourth the amount of extended coffee was used, which resulted in a very dilute brewed beverage (although in accord with vendor guidelines). In addition, lighting in some dining halls was poor during early morning hours. On the other attributes, a significant difference was found in the real coffee flavor; although rating levels were in the intermediate range, the troop-issue beverages were rated significantly higher than extended beverages, which confirmed laboratory evaluations. Neither bitterness nor mouthfeel attributes were significantly different between the coffees, and the beverages were rated equal in acceptability.

In the cross tabulations, no significant differences occurred when both coffees were grouped by recipes used in dining facilities. That this was an effect of conditioning to a given method (recipe) of preparing coffee in consumers' respective dining halls was suggested when troop-issue and extended coffee responses were separated by recipe group. Here, the difference in real coffee flavor between the troop-issue and the extended coffee reemerged under both recipe ranges. In the "three-fourths to full" recipe group, there was a somewhat greater difference in bitterness between the coffees than seen in the responses averaged over all dining facilities. Intensity levels, however, were low (in the intermediate to slightly weak range). These mean values were not analyzed for statistical significance.

This field evaluation generally confirmed laboratory findings. Even under conditions where the brewing recipe was not controlled, consumers indicated a difference in coffee strength (real coffee flavor). However, as in the laboratory tests this difference was not reflected in ratings for acceptability.

Other Observations. The incidence of consumers taking coffee at the breakfast meal was estimated at 15 percent, based on the numbers of consumer opinion cards collected and recorded headcounts. This was considerably less than the 43 percent statistic reported in a recent U.S. coffee consumption survey for the 20 to 29 age bracket.[12] In addition, anecdotal accounts by military food planners and food service personnel regarding the importance of coffee to military personnel (e.g., morale) are refuted by this observed incidence of consumption.

The author tasted extended coffees brewed in dining halls already using one third to one half the recommended recipe. They were watery and lacked coffee flavor identity although color (darkness) appeared typical. Coffee drinker ratings suggested these beverages were acceptable; however, it would appear advisable to establish a minimum recipe level for the R&G coffee ingredient based upon current AFRS guidelines in order to achieve a minimum level of quality. If this procedure were implemented at a military installation such as Fort Campbell, which may represent a regional preference and conditioning of consumers on strength of coffee beverages, a monetary savings on coffee would be unlikely.

[12]Anonymous. United States of America Summary of National Coffee Drinking Study Winter 1981. London, England: International Coffee Organization September 1981.

B. Pease AFB, NH

The evaluation was of troop-issue R&G coffee with and without R&G dark roast barley (RGB). Results are shown in Table 23. Of the 40 cards collected at each of the two breakfast mealtimes, 38 were completed in a valid manner. Headcounts each day were 200 patrons; thus about 20 percent of the consumers took coffee. The only significant difference in consumer ratings between the two coffees was for the appearance attribute. As in laboratory consumer tests, the 50 percent RGB-substituted beverage was perceived as darker than the beverage brewed from one hundred percent troop-issue R&G coffee. Although consumers perceived more real coffee flavor in the troop-issue than the RGB-substituted beverage, differences were not significant. In addition, there were no significant differences between the beverages in bitterness, mouthfeel or acceptability.

Numbers of responses were low at this location, largely because an unanticipated alert was imposed on the Base immediately prior to the survey visit. However, findings suggested that under garrison conditions, a 50 percent RGB-substituted R&G coffee would be equivalent in quality-related attributes and acceptability to a beverage brewed from 100 percent R&G coffee, corroborating previous laboratory findings.

Table 23. Pease AFB, NH Survey Barley (RGB) Substituted R&G Coffee

	Day 1+	Day 2+
Blend, percent*	100 TI -0- RGB	50 TI 50 RGB
Number of Responses	38	38
Attributes Rated		
Appearance	6.6 ± 1.1**	7.2 ± 1.3
Real Coffee Flavor	5.3 ± 1.8	4.8 ± 1.8
Bitterness	5.3 ± 2.0	5.1 ± 1.3
Mouthfeel	4.9 ± 1.4	4.8 ± 1.8
Acceptability	5.7 ± 1.9	6.0 ± 2.0

* Recipe used by the facility was a three-quarters full, eight fluid ounce coffee cup.

** Significantly different in t-test, p=0.03. Other attribute differences between the two beverages were not significant.

+ Usage of whitener and sugar reported by respondents was as follows (%): Day 1 - black; 13.1; whitener - 15.8; sugar - 23.7; whitener + sugar - 47.4. Day 2 - black - 31.6; whitener - 18.4; sugar - 13.1; whitener + sugar - 50.0.

C. Fort Devens, MA

The evaluation was of troop-issue coffee blend and a new blend containing 30 percent Ivory Coast Robusta coffee. Results are presented in Table 24. Although the laboratory experiment with preroast blended coffees produced no significant differences in quality-related attribute ratings or acceptability (Series E, Step 2-Table 21), the dining hall surveys indicated significant differences. The appearance of the reference (troop-issue) blend was rated significantly darker than the revised blend. There was also a significant difference in perception of real coffee flavor; the difference might have been due to the prior "conditioning" of the dining hall respondents to the reference beverage which they drank every day. It was unlikely that laboratory panelists were conditioned to any particular coffee blend, particularly the troop-issue blend. There was a significant difference in mouthfeel between blends in the same direction as flavor attribute ratings. Mouthfeel ratings across blends were significantly different between dining halls, but the difference was small. A significant interaction occurred in acceptability ratings, and there were no significant main effects, either between blends or dining halls. However, in a post hoc statistical routine, a significant difference was found between dining halls for blend B (revised) and for dining hall 2 between blends. These effects must considered nullified by the interaction, however.

The results suggest that under actual operating conditions the revised coffee blend tested here would be equivalent in acceptability to the troop-issue blend. At the same time, there were indications that consumers recognized that the revised blend coffee beverage was different from the one they were normally served. When the revised blend beverage was examined informally on site, there was no question of the presence of Robusta characteristics; however, they seemed well blended with characteristics of the other coffee beans. Reducing the Robusta level in the blend may reduce the risk of detection and loss of beverage acceptability. Furthermore, having equal ratios of Brazilian and Colombian beans in the blend would effectively reduce the amounts of Brazilian coffees used, which are more subject to crop failures and price volatility than the other blend components.

D. Three Services Evaluation

Controlled recipe evaluation of R&G coffee premixed with caramel-base extender versus the same R&G without extender. Survey results are displayed in Table 25. The main effect of coffee recipe was significant for the four quality-related attributes and acceptability. Post-hoc tests using the Student Neuman-Keuls analysis of all coffee beverage pairs revealed the differences noted.

Appearance of the full recipe coffee (A) and half recipe coffee with extender (B) did not differ significantly. Both beverages were perceived by respondents as significantly darker than the half recipe coffee (C) without extender. The findings between coffees A and B corroborate the Fort Campbell,

Table 24. Fort Devens, MA Survey of Two R&G Coffee Blends

Blend (%)*	A. 70 BR## 30 CO 0 IC (Reference)	B. 35 BR## 35 CO 30 IC (Revised)	Mean Dining Hall
Attributes Rated			
Appearance**			
Dining Hall 1	6.5 ± 1.5 (127)	5.9 ± 1.6 (100)	6.2
Dining Hall 2	6.6 ± 1.4 (88)	6.1 ± 1.5 (78)	6.4
Mean, Blend	6.6+ (215)	6.0 (178)	
Real Coffee Flavor			
Dining Hall 1	5.5 ± 1.6	4.9 ± 1.6	5.2
Dining Hall 2	5.4 ± 1.3	4.7 ± 1.6	5.1
Mean, Blend	5.5+	4.8	
Bitterness			
Dining Hall 1	5.0 ± 1.9	4.8 ± 1.9	4.9
Dining Hall 2	5.0 ± 1.7	5.0 ± 1.7	5.0
Mean, Blend	5.0	4.9	
Mouthfeel			
Dining Hall 1	5.1 ± 1.3	4.7 ± 1.1	4.9++
Dining Hall 2	4.8 ± 1.2	4.4 ± 1.5	4.6
Mean, Blend	5.0+	4.5	
Acceptability			
Dining Hall 1	6.0 ± 1.9	6.2 ± 1.9	6.1
Dining Hall 2	6.3 ± 1.7	5.6 ± 2.0	5.9
Mean, Blend	5.0#	4.5	

* Recipe was approximately three gallons per pound, per AFRS C. Beverages No. 5(2), automatic urn.

** Numbers in parentheses are valid responses collected in each dining facility, each day. They were the same for each attribute and are only shown for appearance.

\+ Significantly different, $p \leq 0.05$. Differences between individual dining halls also significant, $p \leq 0.05$.

++ Difference between dining halls significant, $p \leq 0.05$.

\# Interaction term significant, $p \leq 0.01$. Difference between blends significant, dining hall 2, $p \leq 0.01$. Difference between dining halls significant, blend, $p \leq 0.05$.

The following whitener and sugar usage was reported by respondents. By coffee blend (a) Reference(%): black - 30.2; whitener - 13.0; sugar - 12.6; whitener + sugar - 39.1; no response/incorrect - 5.1. (b) Revised (%): black - 25.2; whitener - 12.4; sugar - 16.3; whitener + sugar - 36; no response - 10.1

Table 25. Army, Air Force, and Navy Survey, Three Coffee Beverages

	A. Full Recipe	B. Half Recipe with Extender E1	C. Half Recipe without Extender
Beverage Surveyed*			
Attributes Rated**			
Appearance	6.6a	6.7a	5.6b
Real Coffee Flavor	5.6a	5.0b	4.5c
Bitterness	5.4a	4.8bc	4.6c
Mouthfeel	5.2a	4.8b	4.5c
Acceptability	6.2a	5.9a	5.4b

* The reference "full" recipe was established for all three survey sites as approximately three-fourths of the amount called for by AFRS Card C Beverages 5(1) and 5(2) for automatic coffee maker and automatic urn, respectively.

** Mean values are averaged across the three Services surveyed. Number of responses = 1,010. For each attribute, mean values followed by different letters are significantly different.

KY, survey in which the relationship between "full" and "half recipe coffees with extender" was maintained but recipe amounts were not controlled. The result did not confirm laboratory studies with this type extender wherein half recipe extended coffees were, under more controlled viewing conditions, rated significantly darker than standard recipe coffees without extender.

For the other descriptive attributes, real coffee flavor ratings differed significantly among the three coffees: coffee beverage A was highest rated followed by B (with extender) and C (without extender). As in other tests, the higher rating for coffee B over C could be attributed to the extender. Coffee A was also rated significantly higher in bitterness than coffees B and C, which were not significantly different from each other. Mouthfeel ratings likewise differed significantly among the three coffees and, as occurred with the real coffee flavor rating, the higher mean value for coffee B over coffee C was probably due to the cue provided by the extender. With respect to these attributes, the same trends in rating levels and direction were found as in the Fort Campbell survey and previous controlled recipe laboratory experiments. In the two df ANOVA, there were no significant main effects of test day or test site (military installation).

The ANOVA for acceptability ratings yielded significant test site as well as coffee recipe main effects. Although post-hoc analyses were not computed for significant differences among test sites the services mean ratings across the three coffees ranked as follows: Air Force, 6.2; Army, 5.7; Navy (excluding shipboard survey), 5.6.

Respondents also indicated how they drank their coffee: black, with cream (whitener) and/or sugar. A statistical analysis was performed to determine whether this use affected acceptability of the three recipes. In this analysis (not shown in Table 24), the main effects included were coffee, site and whitener/sugar use. The main effect of test day was omitted, since this variable was shown not to be significant in the original ANOVA. In addition to the main effects, a coffee by whitener/sugar interaction was included in the model. Separate ANOVAs were computed for all possible combinations: sugar only, cream only, and cream and sugar. In none of the three analyses was the interaction significant. Thus, the use of these additives did not moderate acceptability of the three coffee recipes.

Significant differences in acceptability among the three coffee recipes are indicated in Table 25. Pairwise comparisons between coffees yielded significant differences between recipe A (full strength R&G) and C (reduced strength R&G), and between recipe B (reduced strength R&G with extender) and C. Recipe A was rated higher in acceptability than recipe B, but the difference did not reach the preset statistical criterion ($p=.05$). Thus, the addition of the extender improved the acceptability of the 50% reduced strength recipe and made it comparable to that of the full strength recipe. However, although recipes A and B were comparable in terms of acceptability, this survey, as did previous laboratory and field evaluations, confirmed that there were differences between the two recipes on the descriptive attribute scales.

CONCLUSIONS

Series A. Roasted and Ground Coffee

Using the consumer sensory methodology developed for coffee extender and substitute experiments, it was found that (1) consumer panelists could not distinguish among the present troop-issue coffee blend and best-selling regular and high yield consumer brands of roasted and ground coffee, (2) there were no differences among troop-issue R&G coffees produced by three vendors, and (3) by reducing the quantity of troop-issue coffee in brewing recipes by 25 percent, a significant decrease in flavor/taste attribute perceptions was obtained, but acceptance levels were not affected significantly.

Series B. Caramel-Based Extenders

No differences were found in consumer panel perceptions of coffee beverage quality-related attributes or acceptability among four commercial coffee extender products evaluated in this study. Thus, although there were formulation differences in ingredients of lesser predominance than caramel, this class of extender products could be considered generically equivalent.

In appearance, laboratory consumer panelists rated half-reference recipe coffee beverages with extender significantly darker than reference recipe beverages without extender. This finding was not duplicated in field studies. The real coffee flavor and bitterness attributes were, however, perceived to be significantly higher for the reference than for extended coffee beverages. Ratings for the mouthfeel attribute followed the same trend as for the two flavor/taste attributes; extended beverages were rated on the watery side of the category scale; and, in the majority of experiments, differences from reference beverages were significant. Ratings on these attributes for half-reference recipe coffee beverages without extender were typically significantly lower than reference recipe and extended half-reference recipe beverages. Since the amount of R&G coffee used in half-reference recipe beverages with or without extender was the same, these data suggested that the main functions of the extender products were to (1) add back color lost by reducing R&G coffee in brewing recipes and (2) through the appearance cue, create the impression of a "normal" level of real coffee flavor, bitterness, and mouthfeel. Analyses of the coffee beverages indicated that extracted solids levels were directly proportional to the amount of R&G coffee used in a recipe plus the extender product, when added. There was no indication that extender products increased the solids extracted from R&G coffee.

Although consumer panelists gave evidence they could discriminate between reference recipe and half-reference recipe coffee beverages with extender, differences in acceptability ratings were not significant. However, extended beverages were typically rated lower then the reference beverages, and in no instance did extended coffee rate significantly higher than reference beverages. When included in an experiment, half-reference recipe beverages were rated significantly lower than both the other beverages. Thus, at the half recipe level, the presence of an extender product in the beverage produced a significant effect on acceptability, as it did on the other quality-related attributes.

Field test findings generally validated laboratory data on this class of extender products. The Fort Campbell, KY, test, in which brewing formulas across dining facilities were highly variable, indicated agreement, particularly with respect to the real coffee flavor attribute and acceptability. The three-services test, in which brewing recipes were controlled and the half-reference recipe without extender included, showed agreement with laboratory data with respect to the other attributes (exception: appearance) rated as well.

There was no clearcut evidence from laboratory experiments that the presence of an extender product in brewed coffee beverages would prolong hold time at reference recipe levels of R&G coffee. At half-reference recipe levels, no significant changes in coffee beverages were noted over a three-hour holding period. Significant decreases, however, occurred over the same holding period, notably in real coffee flavor, bitterness, and acceptability when full reference recipe coffee beverages, prepared from both the preblended extended and regular unextended troop-issue R&G coffee, were evaluated. It is possible that dilution (half recipe level) was the primary factor implicated,

inasmuch as a weaker coffee beverage would make sensory detection of adverse quality changes more difficult.

Series C. Grains

At 33 and 50 percent substitution levels in the standard military coffee brewing recipe, a dark roasted and ground wheat product produced significant changes in appearance (darker than reference recipe beverage) and the three flavor/taste attributes rated (lower than reference recipe beverage). There were no significant differences in mouthfeel, and extracted solids levels in both unaltered and substituted beverages were the same. The attribute differences noted, however, did not result in significant differences in acceptability. Ratings for the substituted beverages were equivalent to a consumer retail brand containing a R&G wheat substitute.

When evaluated with reference recipe coffee beverages, three forms of roasted and ground barley, unmalted, malted, and pearled, produced no significant changes in flavor/taste and mouthfeel attributes or in acceptability when substituted in coffee brewing recipes at levels up to 50 percent. A significant darkening, however, was noted by consumer panelists at the 20 percent substitution level for malted barley and at 25 percent levels for medium and dark roast unmalted barleys. Of the two grains evaluated, consumer panel data indicated that the barleys produced the least amount of change in attributes and acceptability compared to wheat. Field testing of the dark roasted and ground barley substituted at 50 percent confirmed laboratory findings. Extracted solids levels of barley-substituted coffee beverages was 1.5 to 2 fold higher than beverages brewed only from the same weight of R&G coffee.

Series D. Miscellaneous Extenders

Of the three ingredients or products evaluated under this classification, none showed sufficient promise to warrant more extensive evaluation. Coffee beverages with the commercial extender (CE) product, in combination with 40 and 50 percent R&G coffee reduction, rated significantly lower in flavor/taste attributes and mouthfeel than the reference recipe beverage. In addition the CE product impeded passage of coffee extract through brewer filters and added a noncoffeelike off-flavor characteristic to the beverage. Instant coffee, used to replace extracted R&G coffee solids at two recipe levels, decreased the level of flavor/taste attributes and mouthfeel compared to beverages brewed from R&G coffee only. This may have been due to the aromatics lost by replacing R&G coffee with the instant product. Differences between R&G and the R&G/instant mixture were more dramatic at the half reference recipe levels. At each recipe level, differences in acceptability were not significant but differences between recipe levels were significant. Beverages containing instant coffee solids seemed to take on the overall character of instant coffee itself. Comparison of a standard troop-issue reference recipe coffee beverage with two commercial R&G coffees containing chicory indicated that the latter were equivalent from a statistical viewpoint in all characteristics except appearance, which consumer panelists perceived was significantly darker. The relatively higher cost per pound of R&G coffees

with chicory compared to all coffee products would preclude further consideration of their use.

Series E. Robusta Coffee Beans

1. In preliminary experiments, consumer panel ratings indicated no significant differences in quality-related attributes or acceptability between a reference troop-issue coffee beverage and beverages prepared by substituting 10 and 25 percent levels of two Robusta coffee sources. Informal descriptive examination indicated that Robusta coffee sensory characteristics dominated coffee beverage flavor at the 25 percent substitution level.

2. Coffee blend reformulation experiments revealed no significant attribute or acceptability differences in consumer ratings compared to a reference blend, whether the green coffees were combined before roasting and co-roasted together or whether the blend components were first roasted separately, then combined before grinding. Descriptively, however, it appeared that Robusta flavor characteristics of the brewed coffees were not as evident at a 30 percent level when equal portions of Brazilian and Colombian coffees were used. Field testing of this blend with the standard troop-issue coffee blend suggested that military consumers were somewhat more sensitive to flavor/taste differences than their laboratory counterparts: the reference blend rated significantly higher in real coffee flavor and higher in acceptability (not significant) than the reformulated blend.

In summary, there appeared to exist no extender or substitute, including alternate coffee varieties, which, when used in ways or at levels that would provide significant economic benefit, would both produce no noticeable change in coffee beverage flavor and mouthfeel characteristics and no change in acceptability.

RECOMMENDATIONS

1. A potential exists for reducing military R&G coffee procurement costs without using extenders by lowering the amount of R&G coffee recommended in brewing recipes. Based upon data obtained in this study, the Armed Forces Product Evaluation Committee (AFPEC) recommended the Armed Forces Recipe Service (AFRS) consider a 25 percent reduction in the amount of R&G coffee called for in coffee brewing recipes. AFRS is in the process of adopting this recommendation. Savings may be difficult to estimate, inasmuch as field visits to military dining facilities during this project revealed instances where lesser amounts of R&G coffee than called for in recipes were being used. The change will bring military food service practice into line with other large food service organizations. The policy of adjusting the amount of R&G coffee used in brewing recipes according to consumer preferences, as many military food service personnel say they are now doing, would be preferable to using non-coffee source products and ingredients. Among the most prominent reasons are (1) avoidance of potential legal and consumer problems; (2) potential nonconcurrence of coffee industry trade groups, industry members, and vendors to the military; and (3) no cataloguing, procurement and distribution costs incurred through adding another products(s) to the food

service system. Thus, this course of action is highly recommended as most expedient with or without future increases in green coffee prices.

2. As of this writing, AFPEC has authorized Federal Supply Catalog listing of military blend R&G coffee premixed with caramel-based extender products. The product will be procured through normal channels and depot stocked. If a sufficient number of food service system customers adopt the product for serving to their patrons, it will remain in the system. If not, it will be deleted. This is a prudent procedure to assess system acceptance of a new product. The decision, however, gives rise to major concerns regarding this class of extenders: (1) if food service facilities who have already reduced the amount of R&G coffee in their recipes, in turn, cut this amount in half again, per label instructions, the result will be a dilute but dark color beverage with little coffee identity; (2) although acceptability in short term trials of the extender product is equivalent to the troop issue coffee product now used, it has not stood the test of prolonged use nor has the incident of customer complaints (e.g., weak, watery coffee) been assessed compared to R&G coffee without extenders; (3) should complaints of weak coffee arise, the only recourse for the operator would be to increase the amount of extended coffee used, thereby lessening any cost savings effect, or to switch back to the regular R&G product; and (4) finally, the military may be adopting, even if temporarily, a concept of questionable validity in technical terms as well as with a regulatory agency such as the Food & Drug Administration. It is therefore recommended that the military services proceed with caution in this area.

3. Although from sensory and cup solids standpoints the grains, particularly barley, showed promise as substitutes, three disadvantages may hinder their adoption: (1) bulk transport costs; (2) the need for the coffee roaster to grind the grain, which may be infeasible using equipment designed to grind coffee/ and (3) the opposition of coffee trade associations and coffee roasters themselves. It is probable that added transport and processing costs would increase the cost of using grains to a level comparable to using Robusta coffees. However, perceived benefits to nutrition and general health, such as in the reduction of caffeine levels, as well as general consumer preferences for hot beverages with lower levels of coffee-like characteristics, may cause the grains to be a productive area for future research and development. The military should thus continue to monitor developments in this area for possible future adoption into its food service system.

4. If, in the future prices of one or both components of the present troop-issue R&G coffee blend rise to the extent that extenders or substitutes are called for, partial replacement with a Robusta coffee would be the easiest option for the military to implement for the following reasons: (1) they are already included in the Federal Specification for coffee; (2) coffee roasters can handle them in their processes; and (3) they would generate a minimum of trade association/industry resistance. Robusta coffees are not without their drawbacks particularly with reference to green bean quality as indicated in this report. Furthermore, trade association sources have advised that, in event of scarcity of coffees from other world growing regions, demand for

robustas would likely increase along with their price. Nevertheless, in terms of relative costs, a price advantage would likely exist.

This document reports research undertaken at the US Army Natick Research and Development Command and has been assigned No. NATICK/TR-84/014 in the series of reports approved for publication.

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APPENDIX A

DEVELOPMENT OF CONSUMER OPINION CARD FOR RATING COFFEE BEVERAGES

Because consumer opinion cards in use at the inception of this study were designed to obtain general attribute ratings common to a wide variety of foods, attributes and scales specific to coffee beverages were required. General principles for designing consumer opinion cards were utilized from a previous NRDC effort.[1] The following criteria were viewed as design criteria for the card: (1) attributes to be rated should be understandable to consumer judges both in laboratory and field settings; (2) the attributes selected should be sensitive to manipulations in coffee brewing recipes; (3) to the extent possible, attributes should not overlap, i.e., should not be related wholly or partially to other attributes rated; (4) acceptability should be one of the measures; (5) nine scale categories should be used for both laboratory and field evaluations to facilitate comparison of data; and (6) scales should be unidimensional to facilitate correlation and regression analyses.

In selecting attributes to be rated, coffee industry and sensory scientists were consulted to obtain information on consumer test methodology used by their firms. Claims made by vendors of certain coffee extenders indicated their products would modify certain brewed beverage sensory characteristics which needed to be considered in view of project objectives. In addition, attributes on consumer response forms previously used by NRDC and Troop Support Agency, Fort Lee, VA were considered for appropriateness to project objectives (see Figure A-1a and b).

Evaluation of Version 1, Consumer Opinion Form. The Consumer Opinion Card evolved from two previous paper forms evaluated as part of planned project experiments. Version 1, shown in Figure A-2, was used to assess the need to include both a bitterness and a sourness attribute on the form. This was done as part of the Experiment B-1 study on three commercial caramel-base coffee extenders and the Experiment C-1 study of a roasted wheat substitue. Pearson correlation coefficients were computed between each attribute pair as a measure of independence, Table A-1. Those coefficients significantly different from zero ($p \leq 0.05$) are indicated with an asterisk(*). Three sets of coefficients were computed as indicated in the table.

Discussion. For the coffee beverages without caramel extenders, (part a, Table A-1), all correlations between quality-related attributes were significantly different from zero. In contrast, there was no significant association between the appearance attribute and any of the flavor/taste attributes or mouthfeel in the case of the half-recipe coffees with extender (part b, Table A-1). This was apparently due to the similarity in individual ratings among the three extended coffees, since as indicated in Table 4 in the text, all were rated significantly darker than coffees without extenders but not significantly different from each other. The variance-covariance

[1]D. Waterman, N. Cobean and H. Meiselman. Evaluation of Five Food-Rating-Feedback Cards: Final Report. NATICK/TR/76-58-FSL, March 1976.

Table A-1. Attribute Correlations, Version 1, Consumer Rating Form

a. Full and half reference recipe coffees without extenders, Experiment B-1

N = 140	Appearance	Coffee Flavor	Bitterness	Sourness	Mouthfeel
Appearance					
Coffee Flavor	0.57*				
Bitterness	0.40*	0.61*			
Sourness	0.26*	0.32*	0.56*		
Mouthfeel	0.48*	0.59*	0.54*	0.34*	
Acceptability	0.12*	0.25*	-0.10	-0.23*	0.19*

b. Half reference recipe coffees with caramel-base extenders, Experiment B-1

N = 210	Appearance	Coffee Flavor	Bitterness	Sourness	Mouthfeel
Appearance					
Coffee Flavor	0.05				
Bitterness	-0.01	0.52*			
Sourness	-0.05	0.36*	0.54*		
Mouthfeel	0.03	0.43*	0.39*	0.34*	
Acceptability	-0.16*	0.42*	0.06	-0.12*	0.20*

c. R&G coffee with R&G wheat substitute, Experiment C-1

N = 128	Appearance	Coffee Flavor	Bitterness	Sourness	Mouthfeel
Appearance					
Coffee Flavor	-0.12				
Bitterness	0.14	0.20*			
Sourness	0.13	0.03	0.43*		
Mouthfeel	0.08	0.11	0.30*	0.63*	
Acceptability	0.03	0.04	0.40*	0.61*	0.53*

*Significantly different from zero at $p \leq 0.05$.

statistic across the three coffees ranged from -0.03 to +0.08. No significant association was sufficiently large to be predictive. The smallest associations were generally found between acceptability and the quality-related attributes; thus for all practical purposes acceptability was independent of the other rating scales. Correlation matrices a and b, Table A-1, contained equal numbers of judgments by consumers who evaluated the coffee samples black and with both whitener and sugar. In matrix c, (roasted wheat substitute), consumers evaluated the coffees black, and there was no significant association between appearance and the other characteristics rated. Furthermore, unlike experiment B-1 in the text, coffee flavor ratings were virtually independent of the other scales. A significant positive association emerged between bitterness and acceptability, and there was a relatively high positive relationship between sourness and mouthfeel as well as acceptability. Over the three matrices, there were consistent positive, significant associations between coffee flavor and bitterness, and between bitterness and sourness.

It seemed desirable, for purposes of designing a final version of the consumer opinion card, to eliminate one of the flavor/taste attributes. The relatively low mean ratings for the sourness attribute suggested that consumers either did not perceive it at all or were uncertain about it. Freshly brewed coffee beverages are known to be inherently low in acids, in contrast to beverages that have been held. Furthermore, there was the likelihood of confusing sour with bitter, particularly with untrained and unscreened panelists. Therefore, it was decided to delete sourness from future forms.

Evaluation of Version 2, Consumer Opinion Form. The Version 2 test form, Figure A-3, was used to test the desirability of including an aroma strength scale and a flavor strength scale on the same form, as had been done on the response form shown in Figure 1b. It should be noted that other modifications were made in attribute names: (1) no mention was made of rating appearance before adding whitener (cream) since it had been decided to select coffee drinkers at random; (2) the words "strength of" were deleted from the aroma/flavor/taste attributes since the scale categories themselves described levels of strength or weakness; and (3) the word modifiers for the mouthfeel attribute were changed since experience with the previous scale had suggested that strong coffees were not thick in the sense of being viscous; it was thought the new descriptors would clarify meaning of this attribute. Correlations were obtained from Experiment A-3 reported in the text, which was a coffee recipe study without extenders that included equal numbers of consumer panelists who evaluated the beverages black and with whitener and sugar.

Discussion. Correlation matrices are presented in Table A-2. As with the coffee beverages without extender in Table A-1, a significant association was found between appearance and the other quality-related attributes. The associations were generally greater when coffees were evaluated black than with cream and sugar. Correlations between all other quality-related attributes were also significantly different from zero as in the, Table A-1 data. Interestingly, when coffees were evaluated black, no significant association of aroma or flavor with acceptability was found; when whitener and

Table A-2. Pearson Correlation Coefficients, Version 2 of Consumer Opinion Test Forms, Experiment A-3

a. Both coffee drinker groups

N = 254	Appearance	Aroma	Flavor	Bitterness	Mouthfeel
Appearance					
Aroma	0.44*				
Flavor	0.54*	0.62*			
Bitterness	0.47*	0.39*	0.51*		
Mouthfeel	0.54*	0.44*	0.62*	0.60*	
Acceptability	0.11	0.25*	0.32*	-0.09	0.09

b. Coffees evaluated black

N = 128	Appearance	Aroma	Flavor	Bitterness	Mouthfeel
Appearance					
Aroma	0.42*				
Flavor	0.65*	0.59*			
Bitterness	0.57*	0.40*	0.55*		
Mouthfeel	0.65*	0.46*	0.65*	0.73*	
Acceptability	0.10	0.07	0.17	-0.09	0.06

c. Coffees evaluated with whitener and sugar

N = 126	Appearance	Aroma	Flavor	Bitterness	Mouthfeel
Appearance					
Aroma	0.47*				
Flavor	0.41*	0.70*			
Bitterness	0.36*	0.40*	0.47*		
Mouthfeel	0.40*	0.44*	0.59*	0.46*	
Acceptability	0.11	0.47*	0.46*	-0.10	0.12

*Significantly different from zero at $p \leq 0.05$.

sugar were used, significance occurred. Again, a slightly negative association between bitterness and acceptability was found, indicating a tendency for consumers to rate less bitter coffees more acceptable. Black coffee drinkers indicated a considerably higher relationship between bitterness and mouthfeel than previously. This was likely the result of changing the scale wording.

Finally, a high, though not predictive, association was found between aroma and flavor, particularly among consumer panelists who added whitener and sugar. This suggested that including both attributes as a consumer rating form was duplicative. Since aroma is known to be a component of flavor and since there was no convenient way in this study to focus on the aroma component of coffee under controlled conditions in the laboratory or field, it was decided to delete it from the final consumer opinion test form.

The final version of the Consumer Opinion card for coffee, formated on a 5½ x 8½ inch card, is exhibited in Figure A-4.

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DID YOU SELECT *COFFEE*?

☐ YES (continue answering)
☐ NO (STOP & return card)

After you have tasted the *COFFEE*, please rate it for each of the following characteristics by checking one box in each category.

Temperature		Flavor		Strength		Freshness	
Much Too Hot	☐	Very Bitter/Sour	☐	Very Weak	☐	Tastes Fresh	☐
Too Hot	☐	Bitter/Sour	☐	Weak	☐	O.K.	☐
Slightly Too Hot	☐	Slightly Bitter/Sour	☐	Slightly Weak	☐	Tastes Old	☐
Just Right	☐	Just Right	☐	Just Right	☐		
Slightly Too Cold	☐	Slightly Mild/Flat	☐	Slightly Strong	☐		
Too Cold	☐	Mild/Flat	☐	Strong	☐		
Much Too Cold	☐	Very Mild/Flat	☐	Very Strong	☐	Don't Know	☐

Considering everything, how was the *COFFEE*?

Very Good ☐ Good ☐ Slightly Good ☐ Neutral ☐ Slightly Bad ☐ Bad ☐ Very Bad ☐

Check here if you used: CREAM? ☐ yes SUGAR? ☐ yes NEITHER? ☐

COMMENTS:

Figure A-1a. Consumer opinion card used in NRDC 1976 laboratory and U.S. Navy field evaluations of alternative troop issue R&G coffee blends

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DID YOU DRINK COFFEE? ☐ YES (continue answering) ☐ NO (STOP & return card)

After you have tasted the COFFEE, please rate it for each of the following characteristics by checking one box in each category.

AROMA		SERVING TEMPERATURE		FLAVOR		STRENGTH	
Very Good	7 ☐	Much Too Cold	1 ☐	Very Good	7 ☐	Much Too Weak	1 ☐
Moderately Good	6 ☐	Moderately Too Cold	2 ☐	Moderately Good	6 ☐	Moderately Too Weak	2 ☐
Slightly Good	5 ☐	Slightly Too Cold	3 ☐	Slightly Good	5 ☐	Slightly Too Weak	3 ☐
Not Good/Not Bad	4 ☐	Just Right	4 ☐	Not Good/Not Bad	4 ☐	Just Right	4 ☐
Slightly Bad	3 ☐	Slightly Too Hot	5 ☐	Slightly Bad	3 ☐	Slightly Too Strong	5 ☐
Moderately Bad	2 ☐	Moderately Too Hot	6 ☐	Moderately Bad	2 ☐	Moderately Too Strong	6 ☐
Very Bad	1 ☐	Much Too Hot	7 ☐	Very Bad	1 ☐	Much Too Strong	7 ☐

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Considering everything, how was the COFFEE?

Very Good 7 ☐ Moderately Good 6 ☐ Slightly Good 5 ☐ Neither Good Nor Bad 4 ☐ Slightly Bad 3 ☐ Moderately Bad 2 ☐ Very Bad 1 ☐

COMMENTS:

Figure. A-1b. Consumer rating card used by Troop Support Agency, Fort Lee, VA for garrison evaluations of coffee

Figure A-2. Consumer opinion test form, version 1

Instructions: Proceeding from the upper left to the lower right scales, rate this coffee for each characteristic.

Panelist _____
SAMPLE CODE _____

1 - APPEARANCE (Before adding cream)

9--EXTREMELY DARK
8--VERY DARK
7--MODERATELY DARK
6--SLIGHTLY DARK
5--INTERMEDIATE
4--SLIGHTLY LIGHT
3--MODERATELY LIGHT
2--VERY LIGHT
1--EXTREMELY LIGHT

2 - STRENGTH OF COFFEE FLAVOR

9--EXTREMELY STRONG
8--VERY STRONG
7--MODERATELY STRONG
6--SLIGHTLY STRONG
5--INTERMEDIATE
4--SLIGHTLY WEAK
3--MODERATELY WEAK
2--VERY WEAK
1--EXTREMELY WEAK OR NONE AT ALL

3 - STRENGTH BITTERNESS

9--EXTREMELY STRONG
8--VERY STRONG
7--MODERATELY STRONG
6--SLIGHTLY STRONG
5--INTERMEDIATE
4--SLIGHTLY WEAK
3--MODERATELY WEAK
2--VERY WEAK
1--EXTREMELY WEAK OR NOT AT ALL

4 - STRENGTH OF SOURNESS

9--EXTREMELY STRONG
8--VERY STRONG
7--MODERATELY STRONG
6--SLIGHTLY STRONG
5--INTERMEDIATE
4--SLIGHTLY WEAK
3--MODERATELY WEAK
2--VERY WEAK
1--EXTREMELY WEAK OR NONE AT ALL

5 - MOUTHFEEL

9--EXTREMELY THICK
8--VERY THICK
7--MODERATELY THICK
6--SLIGHTLY THICK
5--INTERMEDIATE
4--SLIGHTLY THIN
3--MODERATELY THIN
2--VERY THIN
1--EXTREMELY THIN

6 - OVERALL ACCEPTABILITY

9--LIKE EXTREMELY
8--LIKE VERY MUCH
7--LIKE MODERATELY
6--LIKE SLIGHTLY
5--NEUTRAL
4--DISLIKE SLIGHTLY
3--DISLIKE MODERATELY
2--DISLIKE VERY MUCH
1--DISLIKE EXTREMELY

Figure A-3. Consumer opinion test form, version 2

Instructions: Rate this coffee on the six scales below.

NUMBER _____
SAMPLE CODE _____

1 - APPEARANCE

9--EXTREMELY DARK

8--VERY DARK

7--MODERATELY DARK

6--SLIGHTLY DARK

5--INTERMEDIATE

4--SLIGHTLY LIGHT

3--MODERATELY LIGHT

2--VERY LIGHT

1--EXTREMELY LIGHT

2 - COFFEE AROMA

9--EXTREMELY STRONG

8--VERY STRONG

7--MODERATELY STRONG

6--SLIGHTLY STRONG

5--INTERMEDIATE

4--SLIGHTLY WEAK

3--MODERATELY WEAK

2--VERY WEAK

1--EXTREMELY WEAK OR NONE AT ALL

3 COFFEE FLAVOR

9--EXTREMELY STRONG

8--VERY STRONG

7--MODERATELY STRONG

6--SLIGHTLY STRONG

5--INTERMEDIATE

4--SLIGHTLY WEAK

3--MODERATELY WEAK

2--VERY WEAK

1--EXTREMELY WEAK OR NONE AT

4 - BITTERNESS

9--EXTREMELY STRONG

8--VERY STRONG

7--MODERATELY STRONG

6--SLIGHTLY STRONG

5--INTERMEDIATE

4--SLIGHTLY WEAK

3--MODERATELY WEAK

2--VERY WEAK

1--EXTREMELY WEAK OR NONE AT ALL

5 - MOUTHFEEL

9--EXTREMELY HEAVY

8--VERY HEAVY

7--MODERATELY HEAVY

6--SLIGHTLY HEAVY

5--INTERMEDIATE

4--SLIGHTLY WATERY

3--MODERATELY WATERY

2--VERY WATERY

1--EXTREMELY WATERY

6 - ACCEPTABILITY

9--LIKE EXTREMELY

8--LIKE VERY MUCH

7--LIKE MODERATELY

6--LIKE SLIGHTLY

5--NEUTRAL

4--DISLIKE SLIGHTLY

3--DISLIKE MODERATELY

2--DISLIKE VERY MUCH

1--DISLIKE EXTREMELY

CONSUMER OPINION CARD

Drink your COFFEE the way you usually do. Add cream, sugar or both if you use them. Then, rate the COFFEE on the 5 characteristics below. For each characteristic, "X" in the box beside the words that best express your opinion.

Appearance		Real Coffee Flavor		Bitterness		Mouthfeel		Acceptability	
9	Extremely Dark	1	Extremely Weak Or None At All	9	Extremely Strong	1	Extremely Watery	9	Like Extremely
8	Very Dark	2	Very Weak	8	Very Strong	2	Very Watery	8	Like Very Much
7	Moderately Dark	3	Moderately Weak	7	Moderately Strong	3	Moderately Watery	7	Like Moderately
6	Slightly Dark	4	Slightly Weak	6	Slightly Strong	4	Slightly Watery	6	Like Slightly
5	Intermediate	5	Intermediate	5	Intermediate	5	Intermediate	5	Neutral
4	Slightly Light	6	Slightly Strong	4	Slightly Weak	6	Slightly Heavy	4	Dislike Slightly
3	Moderately Light	7	Moderately Strong	3	Moderately Weak	7	Moderately Heavy	3	Dislike Moderately
2	Very Light	8	Very Strong	2	Very Weak	8	Very Heavy	2	Dislike Very Much
1	Extremely Light	9	Extremely Strong	1	Extremely Weak Or None At All	9	Extremely Heavy	1	Dislike Extremely

Check here if you: Drank the COFFEE black ☐ Yes; Used Cream ☐ Yes; Used Sugar ☐ Yes

Figure A-4. Final version, consumer opinion card for coffee